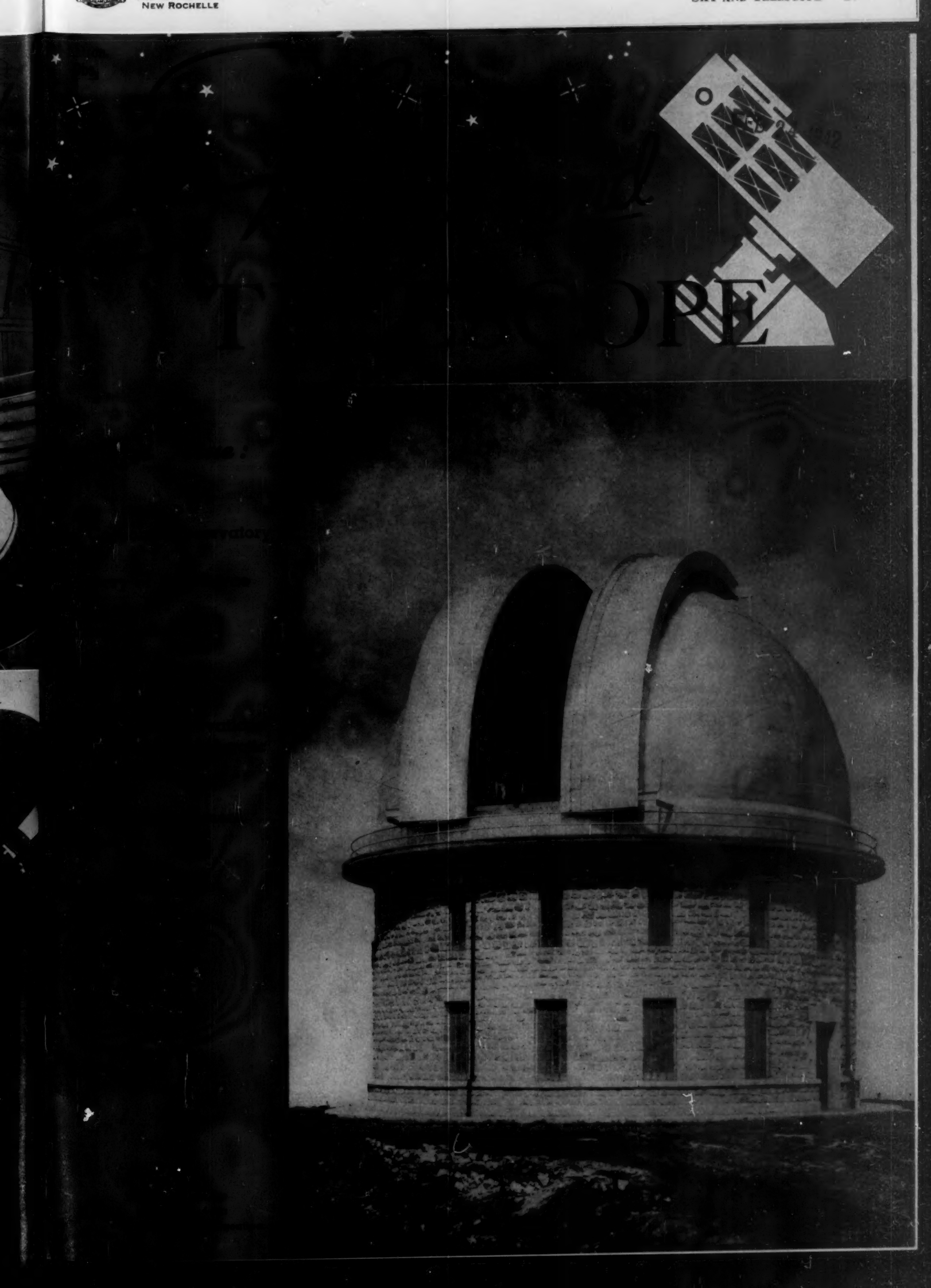
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In Focus

THE back-cover moon photo can be called the Hyginus-Aridaeus region—these clefts run conspicuously across it. Aridaeus extends diagonally to the left from the center, while Hyginus is above and to the right, characterized by a sharp bend just at the crater of the same name.

Most of these objects can be seen with small optical aid. The descriptions are adapted from *Splendour of the Heavens*.

ROSS: The ring crater at bottom center, 18 miles in diameter.

MARE TRANQUILITATIS: Covers bottom center and left.

MARE SERENITATIS: Only a portion of this large plain shows in the extreme lower right.

MENELAUS: A large crater on the south margin of Mare Serenitatis, near right edge of picture. Note the square enclosure to the left of Menelaus.

MACLEAR: Ring plain with low walls just above and left of Ross.

SOSIGENES: Farther above Ross and Maclear, and in line with them, 14 miles in diameter.

ARAGO: In Mare Tranquilitatis in lower left, a deep crater 18 miles across. Note the curved ridges to the west of this crater.

MANNERS: A small, distinct crater above Arago, with a central peak.

RITTER: The large crater on left edge, with two twin craters to its right.

DIONYSIUS: To the right and above Ritter. It is 13 miles across and notable for its brightness.

JULIUS CAESAR: A large horseshoe-shaped walled plain, of which the southwest wall is almost entirely submerged. It appears as a great bay on Mare Tranquilitatis, in lower center above Sosigenes. Note the valley of a chain of craters to the lower right of Julius Caesar.

BOSCOVITCH: The jagged walled plain above and right of Julius Caesar. Its floor is one of the moon's darkest spots.

ARIDAEUS: In full moon all trace of this 140-mile cleft is lost. Just adjoining it on the left is the distinctive crater *Silberschlag*.

HYGINUS: Whenever in sunshine, this cleft is visible in a 2-inch telescope. Note crater-like enlargements along its course.

AGRIPPA: The 28-mile ring plain above left center, with conspicuous central peak.

GODIN: Another large crater to the left of Agrippa.

MANILIUS: A fine bright ring plain in strong sunlight on extreme right edge center. Its walls rise 7,000 miles above its interior.

MARE VAPORUM: The region around and above Manilius.

UKERT: The crater in the mountainous region in upper right, 14 miles across.

SINUS MEDII: Only a small portion of this small sea is in upper center.

TRIESNECKER: An isolated 14-mile crater in upper center on the shore of Sinus Medii.

Sky and TELESCOPE

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The Editors Note . . .

MANY books about Nostradamus, astrologer and prophet extraordinary of the 16th century, have appeared lately. There are biographies, parts of his original French writings, translations, and interpretations, advertised in reputable newspapers and magazines. A widely heralded motion picture short gave striking support to his "prophecies."

We doubt that the public, which provides the market for Nostradamus books, is reading them only for entertainment.

On the occasion of the Modern Library edition, *Oracles of Nostradamus*, which appeared recently, Ralph Thompson, writing "Books of the Times" for the New York *Times*, of Monday, February 9, 1942, says:

"Michel de Nostredame, that grand old sixteenth-century quack, has at last arrived. He has at last made the grade. . . . (He) has been admitted to the Modern Library."

Mr. Thompson tells us later just how the thing works. His formula is considerably nearer the truth than several million people realize:

"This interpreting is the trick, and all you have to do to do it yourself is to be willing. He wrote, so the story goes, about 1,000 different four-line and six-line prophetic stanzas. You take one (there are several hundred in the Ward edition). You stare at it. You translate it from the French, if you know how. If you don't know how, you use Ward's or some one else's translation. You figure out the abbreviations and anagrams, if any. You go into a brown study, or trance. You think of what the stanza may mean. You think of what it might mean. You think of what you want it to mean. The rest is easy.

"In this handy fashion you may discover when the war will end. You may discover what the favorite astrologer of Catherine de'Medici thought about Mussolini and Stalin and Hitler. . . .

"Or you may discover that the revelations of Europe's greatest prophet, no less, rank with the prize humbugs of all time, for almost any of the stanzas can be interpreted in fifteen or fifty different ways, and sooner or later one of them, by the law of averages, is bound to turn out right. . . ."

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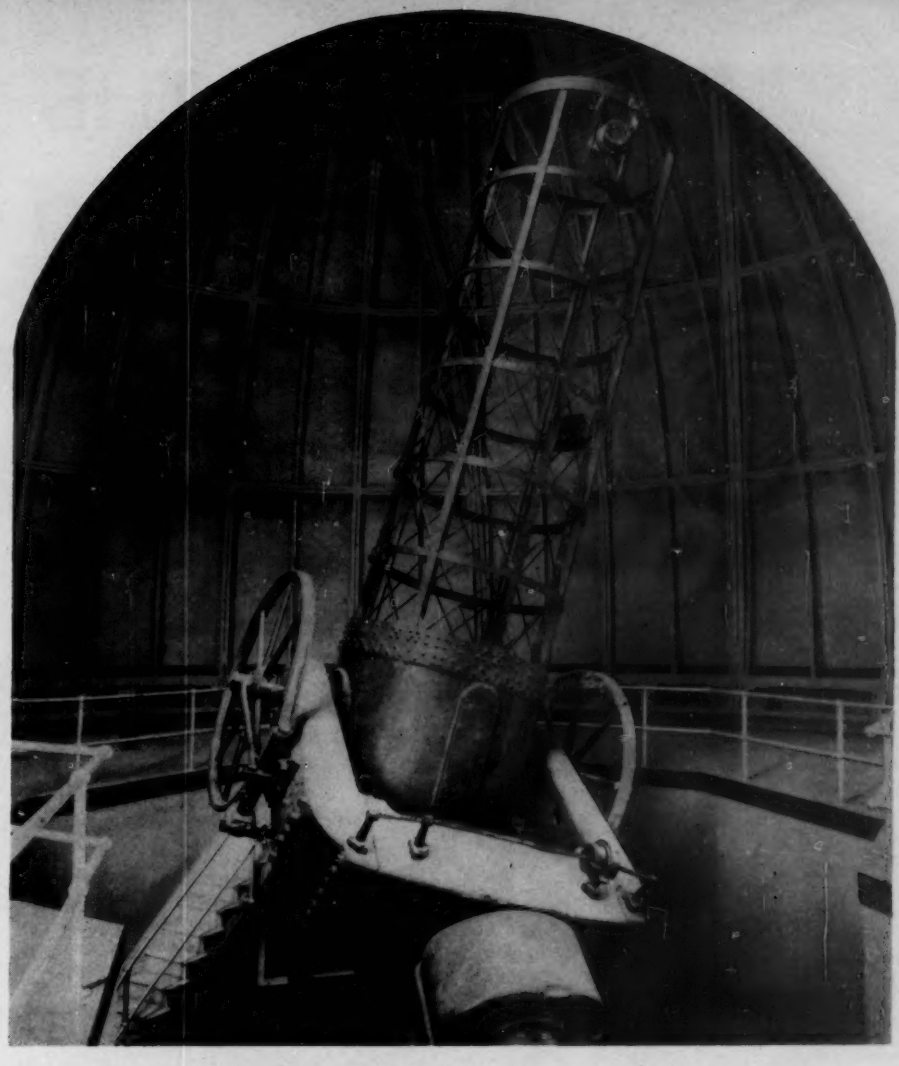
BACK COVER: The northwest central portion of the moon, phase 17 days, 1/2-second exposure with the 100-inch telescope. Photographed by F. G. Pease, September 12, 1919. The direction on the moon of the top of the picture is 60 degrees east of south. The scale is roughly one inch to 40 miles. (See "In Focus" for details.)

SKY AND TELESCOPE is published monthly by Sky Publishing Corporation. Editorial and general offices: Harvard College Observatory, Cambridge, Mass.

Subscription: $2.00 per year in the United States and possessions; $2.50 foreign (including Canada). Single copies: 20 cents. Make checks and money orders payable to Sky Publishing Corporation; send notice of change of address 10 days in advance.

Entered as second class matter, April 28, 1939, at the Post Office, New Rochelle, N. Y., under Act of March 3, 1879.



The 60-inch reflector at the Bosque Alegre astrophysical station.

The Cordoba Observatory

By Enrique Gaviola, *Director*

THE Cordoba Observatory is starting on a new field of work. Having dedicated 71 years of activities to astrometry, it starts now on the broad field of astrophysics with the completion of the 60-inch reflector at the Bosque Alegre astrophysical station. This is situated 30 miles southwest of the old observatory, upon the Sierra Chica, at 4,100 feet altitude.

After many years of planning and construction, the powerful reflector is now in use. The first observations were made on the first day of December, 1941. Planetary and star images proved to be excellent. Observations were made at the first Cassegrain focus using an equivalent focal length of 103 feet. The telescope can also be used at the Newtonian focus with a focal length of 24 feet 6 inches, and at the second Cassegrain focus, sending the cone of light through the hollow polar axis, with an equivalent focal length of 214 feet.

The mounting, of the fork type, was built by the Warner and Swasey Company in 1921-22. The glass for the 60-inch parabolic mirror was obtained from St. Gobain in France. After several unsuccessful attempts by various hands, it was sent in 1938 to J. W. Fecker in Pittsburgh, Pa., where it was finally figured by Mr. Fecker in December, 1939. The writer controlled the final figuring and made the acceptance tests.

The Newtonian diagonal and the two Cassegrain mirrors were ground, polished, and figured at the optical shop of the Cordoba Observatory by R. Platzeck, the writer, and their assistants. The Cassegrains have been figured to a precision of a few hundredths of a wave length of light, three or four times better than "optical perfection." Pyrex 12½-inch disks were used. The flat diagonal was made on an elliptical St. Gobain cast.

The plateholder—made at the observatory under the direction of its chief mechanic, Angel Gomara—allows fine movements in declination and right ascension and permits also correction for rotation of the field. It has two guiding microscopes situated on the sides of the plateholder proper.

Dr. Gaviola is director of the Cordoba Observatory.

The observing platform, containing a crane capable of lifting up to six tons, was also built at the observatory's mechanical shop by Mr. Gomara. It hangs from carriages running along rails attached to the dome. It can be raised, lowered, run along a meridian of the dome, and turned around together with the dome structure. All movements are produced by electric motors and controlled by the observer himself.

The spectrographs that are going to be used with the telescope are being built in Cordoba. The optics of the medium-sized portable spectrograph have been completed. The mounting is under way. It is a "reflecting" spectrograph composed of a Cassegrain collimator of novel design, a 4-inch Wood aluminum grating with light concentrated in one first-order spectrum, and a Schmidt camera of 40 centimeters focal length. The spherical correction of the Schmidt is included in the figuring of the collimator, so there are only four aluminum reflecting surfaces (including the grating), and no absorbing element. It can therefore be used for visible light as well as for ultraviolet and infrared. The dispersion obtained is 38 angstroms per millimeter. Two more spectrographs are to be constructed during 1942.

Among the well-known contributions of the Cordoba Observatory to the astrometric knowledge of the southern sky, started 71 years ago and inspired up to the present day by its founder and first director, Benjamin A. Gould, are the *Uranometria Argentina,* the Cordoba *Zonal Catalogues,* the Cordoba *Durchmusterung,* and the two fundamental Cordoba *Catalogues* (the second now being distributed). Henceforth, new contributions in the old field of astrometry and in the nearly virgin field of astrophysics of the southern sky are to be expected.

THE STORY OF BETA LYRAE

By Gerard P. Kuiper
Yerkes Observatory

In the familiar constellation of the Lyre, Beta is at a corner of the "parallelogram" (*arrow*). Vega is the brightest star (*at top*), and Epsilon, the famous double double, is to its left. Harvard Observatory photograph.

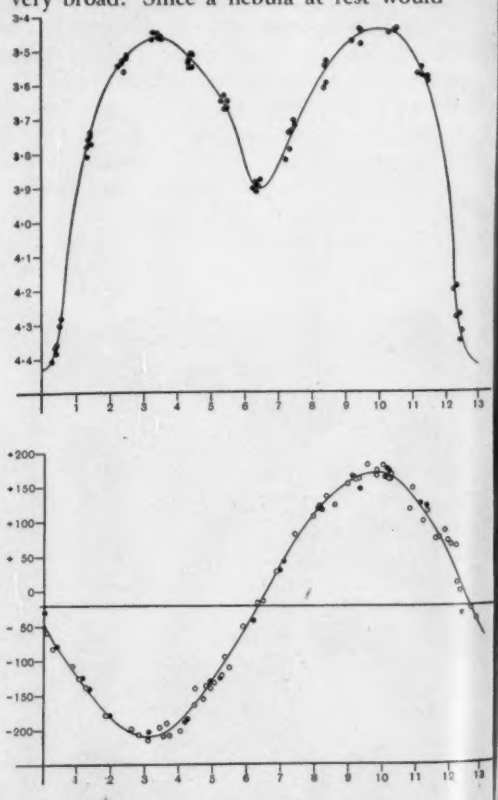
EVER since 1784, when it was discovered that β Lyrae shows periodic variations of its brightness, astronomers have been interested in this star. The principal light variations are shown in the light curve in Figure 1. A comparison of this curve with that of Algol[1] shows some striking differences. The minima are wider; this means that the stars are larger in terms of their mutual distance as compared to Algol, or, what is the same, they are closer together in terms of their sizes. In the second place, we find the maxima to be "round." This proves that the star (or the stars) responsible for the observed light cannot be spherical, because spherical stars outside eclipse show the same brightness in all directions. It is not so simple to get the precise value of the ellipticity of the star (or stars) from the shape of the light curve near the maxima, because if stars are ellipsoidal their light intensity over the surface is not uniform. It is found from theoretical studies that the maxima are as bright as they are partly because at that time the largest side of each star shows, and partly because at the same time the brightest areas are visible.

This is all comparatively straightforward. But accurate photometric observations show the presence of two complications. First, the light variations are not the same for each cycle; differences of about 10 per cent in light are found between different cycles. This is certainly not true for Algol and hundreds of other eclipsing variables, which repeat themselves very strictly cycle after cycle. Secondly, it appears that the primary minimum is quite asymmetrical, and even the two maxima on either side are not always equally bright. We must conclude that the system is more complex than just a pair of stars.

Spectroscopic studies support this view. Again a comparison with Algol is useful. Algol shows a simple *B8*-type spectrum with the radial velocity varying in the same period as the light does (apart from a minor complication due to the third body, which causes a small superposed variation of long period). Algol's companion, which should give a secondary spectrum displaced in opposite sense with respect to the mean velocity, is not visible. The case of β Lyrae is much more complex. First, a *B8*-type spectrum is shown, belonging to a star of the same spectral type as Algol, but of higher luminosity; the star may be called a *B8* giant. This star is moving with very large amplitude (367 km./sec.) in an orbit described in about 13 days, the same period as found from the light curve. (See Figure 2.) No secondary spectrum moving in the opposite sense is found. So far the analogy with Algol is close except that β Lyrae appears to be more massive and of greater dimensions.

However, the spectrum of β Lyrae shows much more than the *B8* star. There is a set of strong, broad emission lines, the most prominent of which are due to hydrogen and helium. In addition, there are absorption lines which at first sight resemble somewhat those shown by a *B5*-type star; this spectrum is often called "the *B5* spectrum of β Lyrae." But it is not a normal, complete stellar spectrum. Moreover, its intensity changes tremendously during the 13-day cycle; its strength is greatest (the absorption lines are deepest) shortly after the primary minimum of the light curve. The radial velocity shown by this absorption spectrum does not change very much, and is always one of approach, amounting to about 50 km./sec. relative to the binary. From these facts, as well as from certain abnormal intensity ratios of lines, one may conclude that this "*B5*" spectrum arises from a nebula surrounding the components of β Lyrae; for some unknown reason this nebula is blown off from the system with a speed of about 50 km./sec.

A nebula of this kind should show two distinct spectra, just as the chromosphere and prominences on the sun do: those parts which are projected on the solar disk show an absorption spectrum, while the parts that stick out beyond the solar limb show emission spectra. Similarly, the part of the nebula in front of the *B8* component of β Lyrae must show an absorption spectrum which is superposed on the *B8*-type stellar spectrum, while all the rest of the nebula with exception of the parts hidden by the component stars will show an emission spectrum. We mentioned already that such an emission spectrum is indeed present, but its lines are very broad. Since a nebula at rest would



Figs. 1 (*above*) and 2 (*below*). The light curve and velocity curve of β Lyrae. Note that the average velocity of the system is —20 km./sec., which is just the motion of the sun approaching the constellation of Lyra.

[1]See Dr. Kopal's article in this series, February issue.

show sharp emission lines, it follows that the nebula is not at rest. Since, further, the centers of the emission lines are not much displaced, it follows that the nebula must be in rapid rotation *around* the binary. The rotational velocities will have to reach values up to 300-400 km./sec., as evidenced by the measured width of the emission lines.

Summing up, we have found that β Lyrae is a binary, with one component visible; the whole system is surrounded by a nebula that is expanding with a radial velocity of about 50 km./sec. and rotating with velocities ranging up to 300-400 km./sec. The great change in intensity of the "*B5*" spectrum during the 13-day cycle further indicates that the amount of material in this nebula is by no means uniform over all angles, but that a very definite relation exists with respect to the line joining the components; in other words, these components in some way determine the density distribution in this nebula.

The observations reveal still more facts of importance; but before we consider them we shall examine whether or not the picture so far developed makes sense.

The nebula around the binary is expanding rapidly. It has been observed for 50 years now, and it is safe to assume that this process has been going on for a considerably longer time. The nebula must then be replenished by the binary, and the latter must in some way be unstable. We might have concluded this also from the lack of periodicity of the light curve, as well as from the asymmetry of the minimum.

The question then arises: how can a binary eject matter? A single star ejects matter if it is rotating so fast that gas is shed off at its equator. This process is very probably responsible for most of the *Be* stars (*B* stars with emission lines) which do not occur in binaries. If a binary consists of two components comparable in size, separated by a few stellar diameters, it is inconceivable that ejection of matter should take place. Because the rotation of the components will then tend to occur very nearly in the same period in which the double star revolves, under such conditions the stars are quite stable. But if the components get closer and closer interesting things begin to take place in the binary system.

Instead of keeping the sizes of the stars fixed and their distance decreasing, we may consider the distance of the centers of the stars fixed, and the components increasing in size; then the different shapes are easily shown in one diagram as is done in Figure 3. It has been assumed that the right-hand star has two thirds of the mass of the left-hand star. When the stars are small compared to their separation they are very nearly spherical. As they grow bigger (or closer, as we have seen) they will finally touch each other. When that happens their shape is given by the figure-eight curve passing through *D*, *G*, and *K* of Figure 3. The curves *E-F* and *H-I* show an earlier condition in which the stars are still separated, though appreciably elongated. (It is noted that their shapes are not ellipsoidal, as is usually assumed for simplicity, but egg-shaped, with the sharpest point directed at the other star.)

Suppose now that the stars get still closer, that is, bigger in Figure 3. They will then extend beyond the figure eight; this will go on until they reach the surface passing through *C* and *L*. This is the upper limit to the sizes of the components; if they were still bigger, a funnel would form near *L* through which matter would stream off into space. In the impossibly extreme case of the surface passing through *B* the funnel would be wide open, and a second funnel would be about to form near *B*. This second funnel would become of interest only if the two stars were of very nearly the same mass, so that symmetry in Figure 3 would almost prevail.

Are the components in β Lyrae close enough for these considerations to become of importance? This appears to be the case; while the precise dimensions are difficult to ascertain from the light curve because of many complications resulting from this closeness, it is practically certain that the two components have a common envelope. Once this result is adopted, a number of conclusions follow which are all in agreement with observation, while those same observations could not have been explained on the basis of separated components.

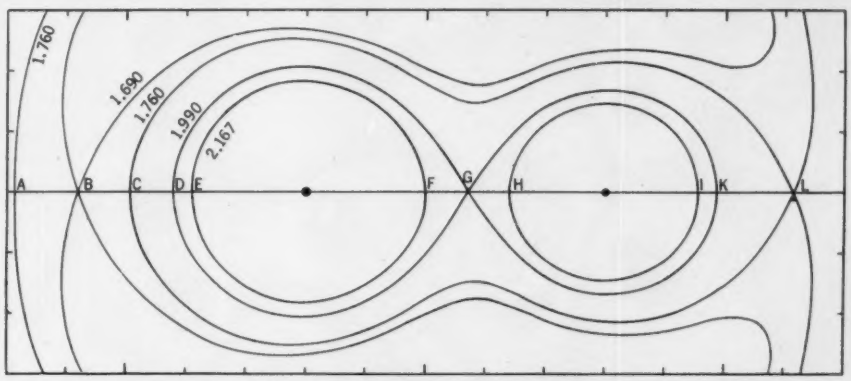


Fig. 3. Possible stellar shapes for the case in which the companion has two thirds the mass of the primary. The plane shown is that of the orbit.

The fact that only one component is visible indicates that the masses are unequal; but the large orbital motion of the *B8* component in connection with the fairly large period of 13 days shows that the companion cannot be very much less massive than the *B8* star itself. So we have a condition as is represented in Figure 3, while the surface of the components may be assumed to be roughly that passing through *C*.

Further investigation shows that if two unequal components have a common envelope, a system of currents will be set up as shown in Figure 4. Gas will stream from the bigger star to the smaller with great speed, but the stream is not symmetrical because the whole system is rotating. Part of this gas will fly off into space near the outside of the companion if the velocity is large enough, or the envelope high enough. If the envelope is as high as *L* in Figure 3, only a very small velocity is required for ejection. The inner part of the stream will swing around over the surface of the companion; its velocity will be less than that of the current leaving the primary. The net result is that the primary loses mass to the companion, and the latter ejects mass into space. It turns out that as a result the stars draw closer together, which speeds up the process. In fact, it can be said that if two sufficiently unequal stars have at first a small common envelope, this envelope will grow, the stars will get closer, and finally the envelope will be high enough for ejection to set in—a star like β Lyrae will result.

We indicated that some observational data were left unused so far. It is now possible to interpret them. About a day before primary minimum a set of extra absorption lines appears in the spectrum, shifted to the red by some 200 km./sec. At that time the position of the observer corresponds to the direction *a* in Figure 4. The observer sees the primary, A, but not the companion, B, which is too faint. The current near *P* will at this time be projected on part of A's visible disk, and we may consider this current responsible

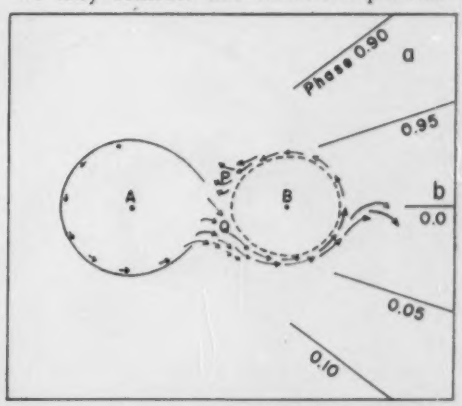


Fig. 4. Currents in a binary in which the components have a common envelope. The streams near *P* and *Q* are actually observed spectroscopically.

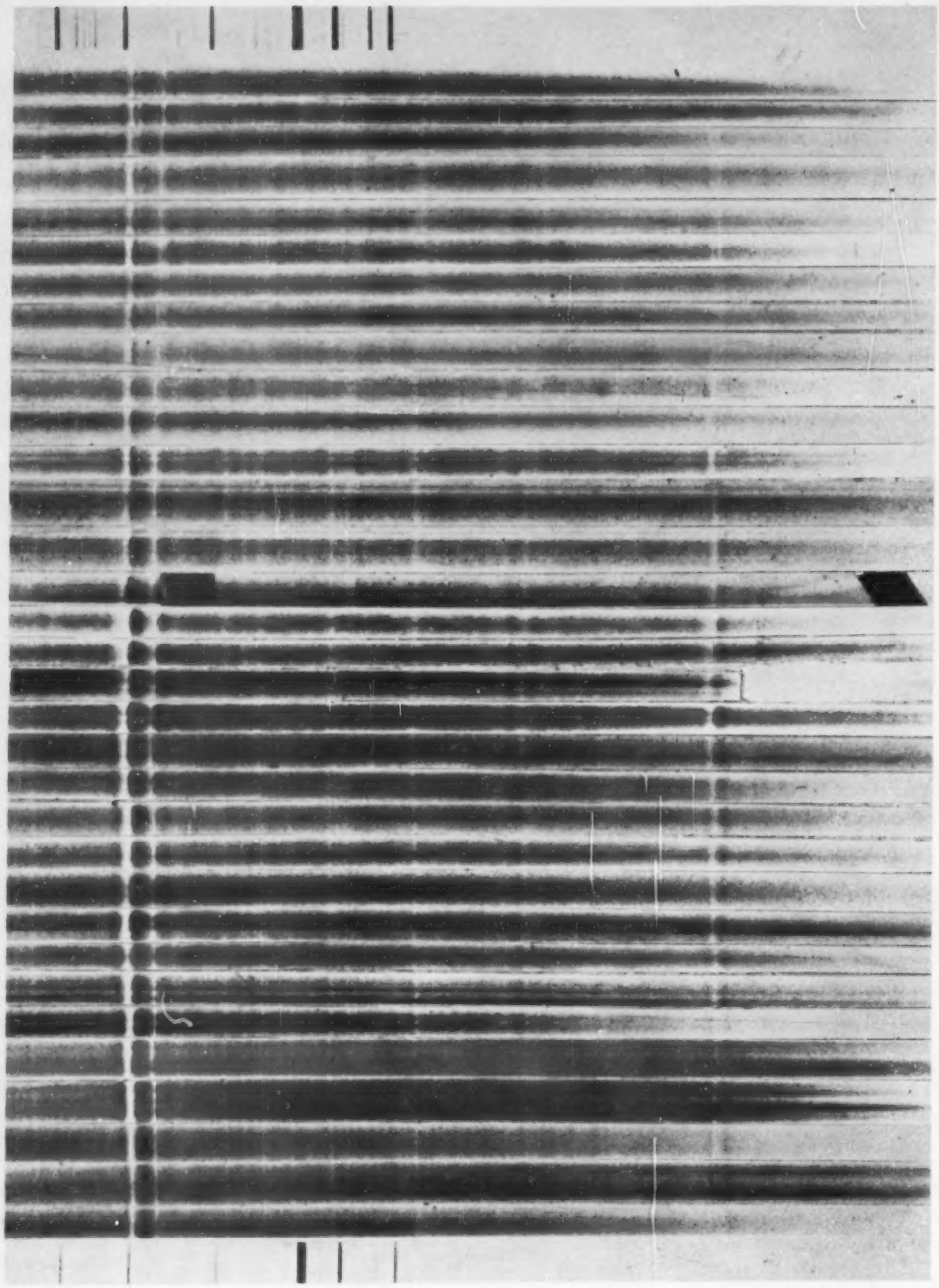


Fig. 5. Spectra of β Lyrae taken near the primary minimum. Note the satellite lines, especially of helium 4472, the conspicuous bright line ⅝ inch from the left edge of the plate. Next to it is the emission line magnesium 4481.

for these extra lines; the measures then indicate a velocity of recession of about 200 km./sec. for that current.

As we approach primary minimum, the extra (or satellite) lines rather suddenly disappear, in a position roughly corresponding to *b*. We may explain this disappearance as a result of an eclipse by B. The appearance and disappearance is well shown by Figure 5, particularly by the helium line 4472.

After primary minimum, satellite lines appear on the violet side, indicating approach, but they are partly blended by the now very strong *"B5"* spectrum, which must be caused by the ejected gas. The velocity of the current near *Q* is thus found to be about 300 km./sec.

One point remains to be settled: what happens to the ejected matter? Computations show that the ejected gas will not return to the binary, but leaves the system in a roughly hyperbolic orbit. The properties of that orbit will, of course, depend on the velocity of ejection, but it appears possible to reconcile the velocities of the currents P and Q with the "velocity of expansion" measured in the *"B5"* spectrum, provided the currents experience a certain amount of friction while moving over B. A quantitative understanding of β Lyrae is therefore actually possible. While the gas is streaming out in a nearly radial direction away from the binary, the double star itself revolves untiringly with its 13-day period. The result is that it winds itself in its own streamer, very much like a giant pin wheel. The picture thus found on the basis of computations is shown in Figure 6.

It is really unfortunate that β Lyrae is not close enough to us to permit visual observation of its streamer. But if it were, we would see it only edge on of course. On the other hand, if our position were at right angles to the plane of the streamer, most of the characteristics now associated with β Lyrae would have disappeared. There would be no eclipse and the light curve would be a horizontal line; the star would not show any variations of radial velocity, and we would not know it to be a binary; the *"B5"* spectrum would be absent; the emission spectrum would not be absent, but the lines would be narrow and constant in position and appearance; there would be no satellite lines at any time. What would we believe this remarkable system of β Lyrae to be? We would call it just another *Be* star!

Perhaps this consideration should be a warning to us—the simplest explanation does not have to be correct. But our assumption of zero inclination is admittedly very special; and our erroneous picture of "just a *Be* star" is entirely due to it. Similarly, in the actual β Lyrae case we are unusually fortunate, because the inclination is very nearly 90 degrees, so that the whole content of the complicated spiral and the currents P and Q pass over the *B8* star, and show their colors (and speeds!). It is undoubtedly due to this circumstance that such a complete analysis and interpretation of β Lyrae has been possible.

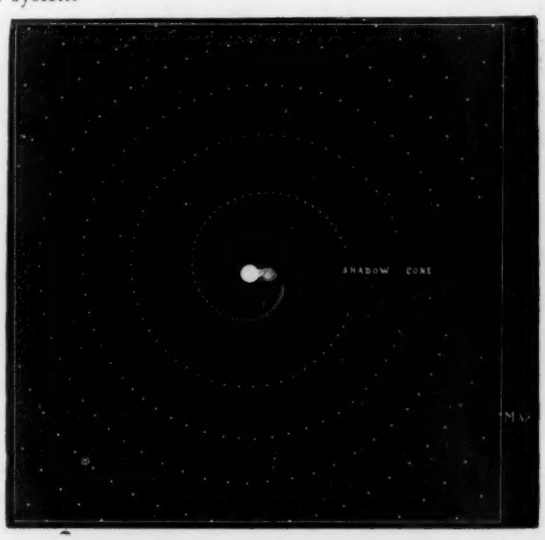


Fig. 6. The system of β Lyrae, the binary and streamer, as viewed from above its plane.

The following engravings used in this article are from: *American Journal of Physics*, Figs. 1, 2, and 6; *The Astrophysical Journal*, Figs. 3 and 5.

Second Astronomer Royal
EDMOND HALLEY

By Private Ralph S. Bates
Massachusetts Institute of Technology

Edmond Halley's best-known portrait was painted by Godfrey Kneller about 1700, and represents Halley in the uniform of a naval captain. The original painting cannot be traced, but it was beautifully engraved by G. White, who died about 1732.

EDMOND HALLEY will be commemorated the world over this year, the bicentenary of his death, as astronomers, meteorologists, and oceanographers pause to do honor to his fruitful scientific career. He was born at Haggerston, England, on October 29, 1656, son of a prosperous soap boiler of London. For his elementary education young Halley attended St. Paul's School. At the age of 17 he entered Oxford, where he soon distinguished himself in astronomy and mathematics; by the time he was 19 he had published a treatise on orbits which dealt a crushing blow to a theory then in vogue to the effect that a planet would move with uniform motion in the part of its orbit around the empty focus opposite the sun.

When Halley presently decided to embark upon an intensive program of observing, he found Flamsteed and Hevelius already doing notable work in the field of positional astronomy. Therefore, instead of entering into competition with them, he chose to supplement their labors by observing the stars around the south pole. Abandoning his college course, in 1676 he prevailed upon his father to finance an expedition to St. Helena, where he landed after a voyage of three months in one of the East India Company's ships. His observations were made with a 24-foot telescope and a "sextant" of 5½ feet radius. Upon his return to England in the following year, he presented Charles II with a map on which he had diplomatically portrayed a new constellation which he styled "The Royal Oak."

Fortune soon smiled on Halley; he was made a Master of Arts at Oxford in 1678 in recognition of his southern studies, and in the same year he was elected a Fellow of the Royal Society.

Halley next made a trip to Danzig to compare observations with Hevelius, who was getting excellent results in measuring angles by using only open sights, as the great Tycho had previously done. Although telescopic observations were presently to render his work obsolete, Hevelius clung to his antiquated methods to his dying day.

In 1680, Halley embarked on a continental tour, which began inauspiciously enough when a storm caused his ship to take 40 hours going from Dover to Calais. Much of his time on the tour was spent in the congenial atmosphere of the Paris Observatory, where he was warmly welcomed by Cassini. Returning to England two years later, he married Mary Tooke, with whom he lived happily until her death 45 years later. They went to live in Islington, where he set up his instruments.

He soon published a well-known paper on magnetism, elaborating a complicated and no longer held theory involving four postulated magnetic poles. He tried to get ship reports from all over the world to test his theory. In 1694, he got from King William III the command of a vessel, the *Paramour Pink*, in which he started for the South Seas, but he was forced back because of mutiny and sickness among his crew. He set out again in 1699, however, and reached 52° south in the Atlantic, when his advance was stopped by great islands of ice of "incredible height and magnitude." Upon his return he published a chart with lines connecting points of equal magnetic declination.

Halley's work in meteorology, geology, and oceanography has been somewhat overshadowed by his work in astronomy. In 1686, using a tabulation of atmospheric pressure against altitude, he concluded that the height of the earth's atmosphere was at least 45 miles.

In 1697, we find him on Mt. Snowdon making barometric observations to determine altitude. His paper in the *Philo-*

Greenwich Observatory has the only onion-shaped dome in the world, which houses a 28-inch equatorial refractor. On the right is Flamsteed House, the oldest part of the Royal Observatory, designed by Wren.

sophical Transactions on "Trade Winds and Monsoons" was accompanied by what is sometimes considered the first meteorological chart. Halley conducted a number of experiments on the evaporation of salt water. These culminated in 1715 in a proposal that the age of the earth might be measured by the degree of salinity of the oceans; although he avoided controversy by discreetly failing to name any particular figure, he apparently thought the earth to be much older than was then commonly supposed. Halley wrote on tides, ocean currents, volume of rivers, and many other topics of interest to geologists. One of his ventures into climatology concerned the distribution of solar radiation on the earth's surface, which he worked out as a function of the sine of the sun's altitude for various latitudes for different days throughout the year.

It has often been said that Halley's greatest discovery was the *Principia*. For about half a century there had been much discussion in scientific circles as to what force held the planets in their orbits and how it varied with distance from the sun. Kepler seems to have had a glimpse of the inverse square law in the 1620's. By 1684, confidence in its validity was growing, but no rigorous demonstration was forthcoming. Halley, Hooke, and Wren became interested in the problem, and Wren finally offered a prize of a book worth 40 shillings to either of the other two who could furnish him with a satisfactory demonstration within two months. Hooke claimed he could give the solution, but never gave any proof. Halley was frankly unable to solve the problem, and after seven months decided to visit Cambridge and put the question straight to Newton.

"What will be the curve described by the planets on the supposition that gravity diminishes as the square of the distance?"

Newton replied without hesitation, "An ellipse."

"But how do you know?" asked Halley.

"I have calculated it," said Newton, and he began searching for his calculations. These he could not find at the time but he sent them to Halley in London in November, and the latter communicated them to the Royal Society early in 1685.

Halley pressed Newton for a fuller account of his discoveries, and, as soon as these were forthcoming, the question arose as to whether or not the Royal Society should finance their publication. However, that distinguished body was financially embarrassed at the time, having then recently published at considerable expense Willoughby's *De Historia Piscium*. In fact, it was about this time that Halley was promised £50 or 50 books on fishes for expenses in connection with meridian measurements. Accordingly, the Council voted that "Halley should undertake the business of looking after the book and printing it at his own charge."

Little more than 30 years of age, Halley undertook single-handed to publish the *Principia*. For several years he was busy editing the manuscript and coaxing Newton to write on. Newton did not seek publicity, had lived almost as a recluse; he hated controversy, especially with Hooke and Leibnitz, and he was thoroughly absorbed in his own researches. The *Principia*, appearing in 1687, is one of the pivotal books in the history of thought, and the Newtonian revolution will doubtless be remembered longer than the "Glorious Revolution" of 1688, when England changed kings.

Halley is best known to the public by the comet which bears his name. If the planets moved in elliptical orbits in accordance with the law of gravitation, Newton reasoned that perhaps comets might move in similar though greatly elongated orbits, and, indeed, he derived the general method of determining cometary orbits from three observations. Halley, who became interested in the problem, succeeded in tabulating the paths of 24 bright comets that had appeared between the years 1337 and 1698. Then he noticed that three of the tracks closely resembled one another, those of the comets of 1531, 1607, and 1682. Suspecting shrewdly that they might be successive returns of one and the same body, he learned upon further search that bright comets had been seen also in 1456, 1380, and 1305. He was thus led to the conclusion that this was one and the same comet, moving around the sun in a closed, elliptical orbit in a period of 75 or 76 years.

Comets had from time immemorial been considered omens of evil or evidences of divine displeasure. Now these bodies were seen to be regular members of the solar system operating under fixed laws. Within a few years we find a theologian like Increase Mather somewhat reluctantly reorienting his thought and writing his essay *Cometographia* in the Newtonian vein.

Halley wrote concerning his comet, "If it should return, according to our predictions, about the year 1758, impartial posterity will not refuse to acknowledge that this was first discovered by an Englishman." Contemporaries must have smiled at a prediction that Halley could hardly hope to live to see fulfilled, but he was

A Lowell Observatory photograph of Halley's comet, as it appeared in 1910. The outer extremity of its orbit is beyond that of Neptune, where the comet will reach its greatest distance from the sun in 1948.

fully vindicated when his comet reappeared on Christmas Day, 1758. By that time Halley had been in his grave 16 years.

Since he had had only an imperfect idea of Jupiter's mass and its retarding effect upon the comet, Halley had not been able to compute its period very precisely. His comet reappeared in 1835 and in 1910; it is due again in 1985.

Fig. 1. — Vénus, entrant sur le bord solaire, est entourée, sur la chromosphère, d'un anneau pâle, dû à l'éclairement de son atmosphère.

Fig. 2. — Mercure, entrant sur le bord solaire n'a pas été vu entouré, du côté de la chromosphère, d'un anneau atmosphérique semblable.

Invisibilité de l'atmosphère de Mercure lors de ses passages.

Halley discovered the value of a transit of Venus (*left*) in determining the distance of the sun. At present, the distance is determined by observing transits of Mercury (*right*).

It was in the course of a series of investigations on the movements of the planets that Halley came to realize the importance of a transit of Venus for determining the distance of the earth from the sun (astronomical unit), and that this was a means for deriving the scale of the solar system by using Kepler's third law. He set forth his method at length and worked out the elements of the transit of 1761, which he did not expect to live to see. In practice, his method is difficult to use, since the times of contact are hard to determine accurately. Nevertheless, the transits of 1761 and 1769 gave astronomers their first really good idea of the sun's distance.

In 1695, after a comparison of ancient and modern eclipses, Halley suggested the secular acceleration of the moon's motion; this "running fast" of the moon causes eclipses to occur earlier than they otherwise would, and has been amply verified many times since Halley made his shrewd guess.

The eclipse of 1715, the first total eclipse to be visible in London since 1140, was observed by Halley from the rooms of the Royal Society. He described minutely what is now known as the corona.

After studying the contemporary position of such stars as Aldebaran, Arcturus, Betelgeuse, and Sirius, and comparing them with their positions as recorded in Ptolemy's *Almagest* (written about A.D. 138), Halley concluded that these stars had moved somewhat across the sky (in a direction perpendicular to the line of sight); hence the announcement, in 1718, of his discovery of the proper motion of the stars, which dealt a severe blow to the ancient view of the immutability of the heavens. The so-called "fixed" stars were really in motion.

In 1703, Halley had been given the Savilian professorship at Oxford. He became Astronomer Royal in 1720 upon the death of Flamsteed. The latter had been providing his own instruments; there were no instruments and no assistants when the new incumbent took over Greenwich Observatory single-handed. After a few years and a few grants of money he was able, at the age of 64, to start another major project, equipped this time with a transit instrument and an 8-foot quadrant. He began a series of observations on the motions of the moon, and carried them on through a Saros cycle of 18 years! These observations were used to prepare tables of immense value to navigators in determining longitudes by the method of lunar distances.

Edmond Halley died on January 14, 1742, in his 86th year. His generous spirit and keen intellect had won him admirers all over Europe. He could have sat at the table of Peter the Great; he chose rather to sit at his telescope.

Returns of Halley's Comet

B.C.

240—Perhaps first recorded mention of the comet.

11—Description by Dion Cassius; comet is thought to be herald of the death of Agrippa.

A.D.

66—Probable Chinese records; probably also mentioned by Josephus as omen of the destruction of Jerusalem.

141—Probably observed in China.

218—Thought described by Dion Cassius; observed by Chinese.

295—Believed observed by Chinese.

373—Believed observed by Chinese.

451—Observed in Europe; Attila the Hun defeated at Battle of Chalons.

530—Possibly mentioned in European chronicles.

607—Perhaps mentioned by Chinese chroniclers.

684—Pictured in the *Nuremberg Chronicle*.

760—Observed in Europe and China.

837—Vivid description in Chinese Matuan-lin catalogue.

912—Probably observed in Europe and China.

989—Probably observed in Europe and China.

1066—Regarded as omen of successful blitzkrieg on England by William the Conqueror; portrayed on the Bayeaux tapestry.

1145—Observed in Europe and China.

1222—Halley's comet (?) regarded as omen of the death of King Philip Augustus of France.

1305—Observed in Europe and China; very bright.

1380—Observed in Europe and China.

1456—Fall of Constantinople in 1453, Turks overrunning southeastern Europe; Pope Calixtus III orders supplications.

1531—Described by Apian.

1607—Seen and later described by Kepler in his *De Cometis*.

1682—Halley observes it, discovers its period.

1758—Returns as predicted by Halley.

1835—Comet is considerably dimmer than on former returns.

1910—Most recent visit.

1985—Next expected appearance.

. . . AND THE WAR

A committee working under the American Association for the Advancement of Science, and in cooperation with the U. S. Army Air Corps, has prepared a provisional outline of emergency courses in astronomy and mathematics. We quote the section on astronomy:

> The emergency course in astronomy should emphasize quick identification of the stars and planets in the evening sky. It should include practice in reading a watch to the second, and numerous simple problems in time, longitude, and latitude, including the Sumner method. These problems should be simple, and many should be worked with the slide rule, or tables. The instructor should insist on quick work to three or four figure accuracy, and also on freedom from mistakes. The course should include more weather and climate than is given ordinarily, including identification of the chief cloud types. It should include an introduction to cartography, or map projections. It will be sufficient to give lectures of a popular type on many subjects taught in the usual course in astronomy.
>
> The committee, and the Army officers working with the committee, did not plan that the schools should give work in the actual use of the sextants. A sufficient number of sextants to permit the actual use of them by any number of the emergency students could not be furnished to the schools. It seemed better to plan that the colleges give the underlying mathematics and astronomy, and the Air Corps itself teach the actual use of the sextants and the other navigational instruments.

NEWS NOTES

By Dorrit Hoffleit

ECLIPSE OF JULY 26, 3928 B.C.

Astronomy has come to the aid of the historian in determining the time of the earliest known Aryan colonization in India. According to P. C. Sengupta (*Journal* of the Royal Asiatic Society of Bengal for August, 1941), this began about 3900 B.C. A solar eclipse, described in the *Rigveda*, had been observed by Atri, one of the earliest settlers in the northern Punjab. From various historical and etymological considerations, Sengupta deduces that the eclipse occurred between the years 4000 and 2400 B.C. He then lists five other conditions that must be satisfied in the determination of the actual date.

It must have been a central eclipse, taking place on the day of the summer solstice or the following day. It must have ended during the fourth quarter of the day at the meridian of Kuruksetra. It was observed from a cave at the foot of a snow-capped peak, either the Himalayas or the Karakoram range. Finally, at the place where Atri was, the eclipse did not reach totality.

Among the 22 central solar eclipses that occurred near the summer solstice within the given time interval, there is one and only one that fulfills all of the required conditions inferred from the *Rigveda*. That one occurred on July 26, 3928 B.C. (Julian calendar).

Sengupta's painstaking researches thus place the date of the first settlement of Aryans in India earlier than previous investigators believed. To most Americans, whose ancestry can be traced but a few hundred years, observations made at so early an epoch might appear to have a purely mythological value. It is a source of satisfaction to find that they conform with astronomically predictable facts.

PROPER MOTIONS FOR SOUTHERN STARS

Publications just received from the University of Minnesota and from the Royal Observatory at the Cape of Good Hope show a boom in the determination of the apparent motions of southern stars.

A catalogue prepared at the Royal Observatory at the Cape has been awaited by astronomers for some time (publication date, 1939). It contains the proper motions and photographic magnitudes of 20,554 faint stars, mostly magnitudes 10 to 11, in the zone —42 to —52 degrees, together with hitherto unpublished spectral classes determined by the late Dr. Annie J. Cannon at Harvard. A previous catalogue contained the corresponding material for the brighter stars in the same zone. The two catalogues combined include 41,397 stars.

Since 1926, Dr. W. J. Luyten, director of the Observatory of the University of Minnesota, has been engaged in the determination of the proper motions of stars throughout the southern hemisphere. His material consists of plates taken with the 24-inch Bruce refractor at the southern station of the Harvard Observatory.

The southern sky was divided into 1,009 regions. In each region a plate of recent date was compared in the blink microscope with a plate taken some 30 years before. Most of the plates show stars down to the 16th photographic magnitude. The stars that showed perceptible motion were marked and measured. Motions were thus determined for approximately 75,000 stars. Incidental to his proper motion survey, Dr. Luyten also discovered over 2,500 variable stars and more than 800 new double stars.

Catalogues of the proper motions for the regions between declination —50 degrees and the south pole (28,535 stars) have now been published by the University of Minnesota Press, under the title, *Bruce Proper Motion Survey. The General Catalogue.* The new catalogues are welcome data to those engaged in studies of Milky Way structure and of the luminosity function.

LOST AND FOUND

A probable remnant of Kepler's famous star of 1604 has been discovered by Dr. Walter Baade, of Mt. Wilson Observatory. After it remained as bright as Jupiter for several weeks, the supernova's decline in brightness was studied by Kepler for two years until the star finally vanished. Since then it has long been the object of careful, though unavailing, search with some of the world's largest telescopes. Now, using new red-sensitive plates, Dr. Baade finds a small fan-shaped cloud very close to the position recorded by Kepler for the bright nova. The newly discovered object is extremely faint on photographs obtained with the blue-sensitive emulsions ordinarily used, thus accounting for previous failures in detecting it.

Kepler's nova is presumably one of three supernovae observed in the Milky Way system within the past 900 years. The Crab nebula in Taurus is believed to have been formed by the supernova of 1054. The second recognized supernova is Tycho's star of 1572, for which no visible "expanding shell" has yet been discovered. At their maximum brilliance, stars of this sort outshine the sun almost 10 million times.

COMET 1942a

On January 31st, Dr. Fred L. Whipple, of Harvard College Observatory, discovered a 10th-magnitude comet on Harvard patrol plates taken on December 28, 1941, and in January. It has a nucleus and a tail less than a degree long. It is not expected to reach naked-eye visibility. On the "Observer's Page" in this issue is a chart showing its path across the evening sky, as well as a list of predicted positions and magnitudes for this month computed by R. N. Thomas.

Announcements of the discovery of new comets by observers in other countries are normally conveyed to Harvard Observatory via cablegram. World conditions at present, however, seriously delay the transmission of such messages both to and from Europe. Although we have received word, via Sweden, of the independent discovery of this comet by the Italian, Bernasconi, on February 11th, we cannot yet be certain either that Dr. Whipple was the first to discover the comet, or that it is the first comet discovered in 1942. But it is the first about which we have any information.

Dr. Roy K. Marshall reports that the spectrum of the nucleus (photographed with the 10-inch Schmidt camera and a Wood replica grating-mosaic at the Cook Observatory on February 13th) shows the H and K lines of ionized calcium in absorption. What is probably the cyanogen emission image of the coma (at wave length 3883 angstroms) is wider than and at least twice as strong as the continuous spectrum of the nucleus between the H and K lines.

It is interesting to note that March 2nd is the date of a three-ring celestial circus. The moon is to be in total eclipse; Comet Whipple will be only about 2½ degrees away; and during the eclipse the 5th-magnitude star, 59 Leonis, will be occulted by the moon. On that evening the comet, about 8th magnitude, will be visible with powerful binoculars or small telescopes. A few days before or after the eclipse, the bright light from the moon will make the comet a most difficult object to locate.

KINGS COLLEGE FELLOWSHIP

The British journal, *Nature*, for January 3, 1942, reports that Prof. Henry Norris Russell, of Princeton University, has been elected to an honorary fellowship at Kings College, Cambridge. In 1902, after obtaining his Ph.D. degree at Princeton, Prof. Russell spent three years as an advanced student at Kings College, collaborating with A. R. Hinks on determinations of trigonometric parallax.

BOMB-EQUIVALENT OF A METEORITE

Astronomers, too, are bomb-conscious. When Dr. H. H. Nininger recently acquired a group of "nicely encrusted aerolites" from the Forest City, Ia., fall of 1890, he at once sought the aid of mathematicians and physicists to determine the bomb-equivalent of the famous meteorite.

At least 300 pounds of meteoritic remnants had been recovered. From the direction from which the meteorite came and the time of day it fell, Dr. Nininger estimates that its extra-atmospheric velocity must have been about 10 miles a second. Had the meteorite reached the ground with this velocity, it would have exploded with the violence of 6,000 pounds of nitroglycerin—six times as destructive as the most efficient bomb yet employed. Of course, the blanket of air surrounding the earth averted much of the catastrophe that might have been. On the other hand, the recovered 300 pounds represent only a small fraction of the mass (probably many tons) that originally struck our outermost atmosphere.

Aries, the first constellation of the zodiac 2,000 years ago, is still a sign of spring.

SPRING

By William H. Barton, Jr.

An understanding of the changes in the sky as the seasons progress helps us to study the origin of ancient spring festivals, many of which are still observed by us today. The Hayden Planetarium demonstration this month combines observation of the constellations of spring with the story of the Easter festival.

"MARCH 21d 6h 11m G.C.T., sun enters Aries, *Equinox,*" says our *Nautical Almanac*. Translated, this says that at 6:11 a.m. by the Greenwich clock on March 21st the sun reaches the first point of Aries, known to many as the vernal equinox. At that moment the sun will cross the celestial equator in its annual journey around the sky. A few years ago an additional sentence followed, "Spring begins." There is really quite a story tied up in that almanac quotation, and quite a few facts are implied.

Out of consideration for our good neighbors south of the equator we no longer mention spring beginning. Down there summer is just ending and autumn is beginning; the seasons are reversed in the two hemispheres. However, most of the terms used through the ages had their origin, as did the science that begot them, in the northern half of the earth. We are just catching up with the times and adapting our words to suit our needs. No longer can we call the point where the sun appears to cross the celestial equator the "vernal" equinox. It is so for us, but for the Anzacs it is the "autumnal" equinox.

The use of the old sign for Aries dates back thousands of years. About 2,000 years ago the point where the sun changed from the southern celestial hemisphere to the northern was in the constellation of Aries, the Ram. The precession of the equinoxes, however, due to that slow wobbling of our earth's axis, has carried the equinox out of Aries and on to the next star group, Pisces. The designation, first point of Aries, has gone along, and is still commonly used, especially among navigators.

Up to a century or more ago it was quite common practice to refer the planets' positions along the sky to the sun's apparent path among the stars—the ecliptic. We still have a system of coordinates based on the ecliptic—celestial longitude and celestial latitude. In the old days the ecliptic was divided into 12 signs, each 30 degrees in length. Today only degrees, minutes, and seconds are used, but the older astronomers divided still finer. We may find in Sir Isaac Newton's *Principia* or in Ferguson's *Astronomy* a position of Venus such as Aries, 15° 36′ 33″ 27‴, meaning 15 degrees, 36 minutes, 33 seconds, and 27 thirds in the sign of Aries.

But to get back to the 1942 equinox. It is just sunrise in the British Isles; at Greenwich the sun rises at 6:03, while out in the islands of the Pacific it is just setting. In the Indian Ocean, not far off the shores of Sumatra, it is noon; the sun is in the zenith on the equator at 90° 52′.9 longitude east of Greenwich. Here in the thick of the conflict such a trivial happening as the equinox will go unheeded. Attention is focused on more practical things.

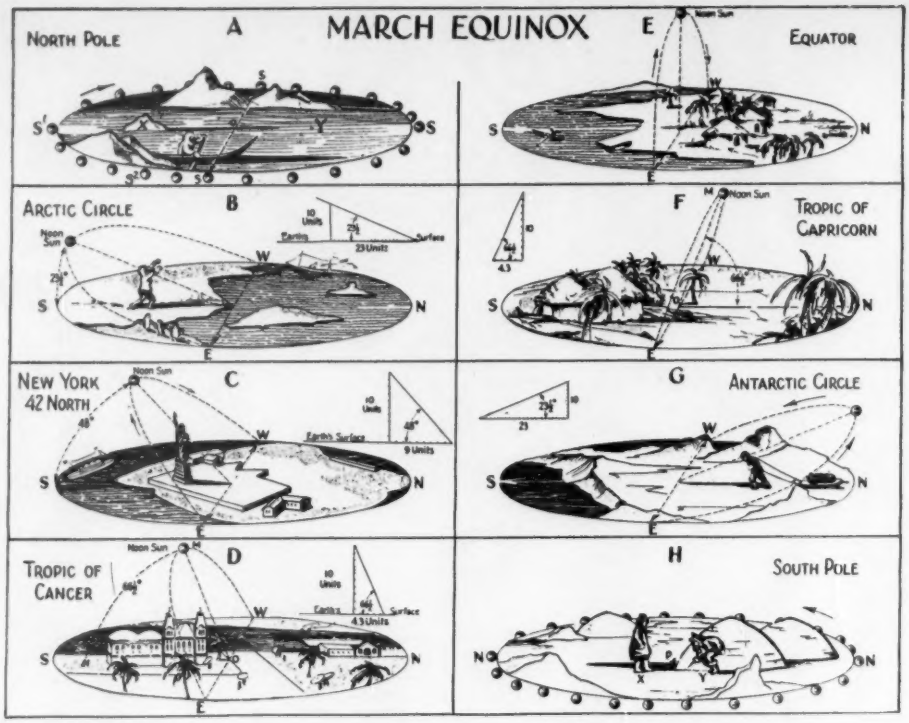
But in olden times the sun's "crossing the line" was an event that called for great ceremonies—the spring festival. After the long hard winter, the promise given by the sun at the winter solstice, when the shortest day passed, was being fulfilled by the length of day catching up with the night. The days and nights were

now equal, hence *equinox*—equal night. We all look forward to the coming of spring, the budding of the trees, the general awakening that nature shows, but to those who lived outdoors and more directly depended upon nature, it really meant life.

March, in which the equinox occurs, has its name derived from the Romans, among whom it was at an early period the first month of the year, as it continued to be in several countries until a comparatively late date. The legal year began, even in England, on the 25th of March (the old equinox date) until the change of calendar in 1752. There seems to be sufficient reason for commencing the year with March in the fact of its being the first season after the dead of the year, when decided symptoms appear of a renewal of growth. For the Romans to dedicate their first month to Mars, and call it *Martius,* seems equally natural, considering the importance they attached to war.

Among the early Saxons March bore the name of *Lenet-Monat*—length month, referring to the lengthening day. This is also the origin of the period of the Christian church calendar known as Lent. Brady, in his *Clavis Calendaria* (1812), quotes as follows from some older source: "that is, according to our now orthography Length Moneth, because the dayes did then first begin to length to exceed the nights; and this moneth being by our ancestors so called when they received Christianity, and consequently therewith the ancient Christian custome of fasting, they called this chiefe season of fast of Lenet, because of the Lenet Monat, whereon the most part of the time of this fasting always fell; and hereof it commeth that we now call it Lent, it being rather the fast of Lent, though the former name of Lenet Monat be long since lost, and the name of March borrowed instead thereof."

The old weather prophets were very observant of the March weather. "A bushel of March dust is worth a King's ransom." That is, if the month is dry, it portends a plentiful season, while an early wet season, on the contrary, is destructive. In old pictures we sometimes find the month portrayed as an old man of fierce aspect, wearing a helmet, no doubt reminiscent of Mars, the god of war. He is leaning on a spade, holding almond blossoms and scions in his left hand, a basket of seeds on his arm, and in his right hand the sign Aries, the Ram. This is supposed to represent the augmented power of the sun's rays, which in ancient hieroglyphics were expressed by the horns of animals.



The March equinox around the world. At the north pole the sun circles the horizon, while at the equator it passes through the zenith. The south pole loses the sun after six months of daytime, and the southern hemisphere autumn begins. Lobeck diagram.

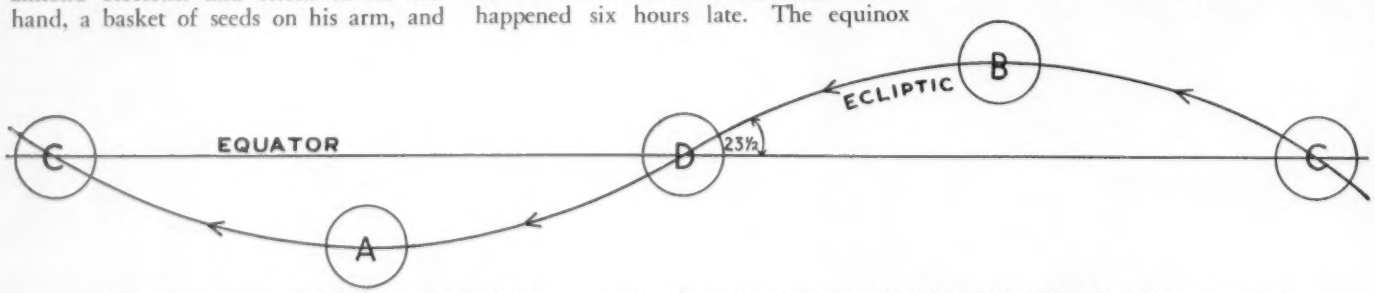
Sometimes the equinox occurs on the 20th, not the 21st. That puzzles people. We list here the times for a few years past:

1935	March 21—13:18	G.C.T.
1936	(leap year) 20—18:58	
1937	21— 0:45	
1938	21— 6:43	
1939	21—12:29	
1940	(leap year) 20—18:24	
1941	21— 0:21	
1942	21— 6:11	

You will notice that the equinox occurs about six hours later on successive years. This is about a quarter of a day. The equinox pays no attention to leap year, for the year is 365¼ days long, despite the calendar. In 1937, for instance, the sun reached the vernal equinox at 0:45, just after midnight. The year 1938 really began about six hours before it should have, astronomically speaking. Therefore all the events of an astronomical nature happened six hours late. The equinox occurred that year at 6:43. And so for 1939. But 1940 was a leap year—an extra day was added. Even though the year began six hours too soon, an extra 24 hours were inserted before the equinox, which was thereby moved forward 18 hours and occurred on the 20th at 18:24. Now for the next four years it is slipping back a quarter day until the next leap year when it will be violently jerked ahead again. That is how leap year keeps our fixed festivals coming in the same season year. after year.

Some of the religious festivals are not fixed in our calendar, for they are held at a given phase of the moon, and that cannot be justified in a solar calendar. Predating Easter and Passover by centuries, pagan festivals were held in the spring at a time of full moon. This was not an arbitrary choice, but was the result of a need for light at night, and the moon furnished it.

It is sometimes said that the Easter rule was adopted in order that the pilgrims might have moonlight in which to travel. But Easter was really originally "pegged"



The annual journey of the earth around the sun, combined with the inclination of the earth's axis, makes the sun appear to travel north and south a range of 47 degrees each year. The points in the diagram above are: A—winter solstice; B—summer solstice; C—vernal equinox; D—autumnal equinox. However, in the southern hemisphere, seasons occur oppositely to those in the northern, from which these places in the sky were named.

New Mexican Observatory Dedicated

ON the morning of Tuesday, February 17th, President Manuel Avila Camacho dedicated Mexico's new national observatory at Tonanzintla in the state of Puebla. The guests of honor were 27 astronomers, physicists, and geologists from the United States and Canada, in addition to many Latin-American scientists, all of whom participated in the Inter-American Scientific Conference.

The major instrument of the new observatory is a 27-31-inch Schmidt camera, optical parts by Perkin-Elmer Corp., and the mounting designed and constructed at Harvard College Observatory. In spite of war priorities and labor shortage, the telescope was finished in the record time of six months. The only larger instrument in Latin-America is the 60-inch reflector of the Argentine National Observatory, described on page 3 of this issue. However, the new Schmidt will surpass the larger instrument in effectiveness for the exploration of the southern sky on a large scale. The detailed story of the new observatory appeared in *Sky and Telescope* for December.

In abbreviated form, we list the titles of the astronomical talks and papers given during the conference:

THE INTERSTELLAR MEDIUM

W. S. Adams, Mt. Wilson, *Identification of Interstellar Lines and Bands*

J. Stebbins, Wisconsin, *Irregularities in Space Reddening*

C. T. Elvey, McDonald, *The Night Sky*

F. L. Whipple, Harvard, *Theory of the Interstellar Medium*

CLASSIFICATION OF STELLAR SPECTRA

W. W. Morgan, Yerkes, *General Problems of Spectral Classification*

A. N. Vyssotsky, McCormick, *Classification of Faint Stars*

B. J. Bok, Harvard, *The Cannon Bureau*

R. W. Wood, Hopkins, *Diffraction Gratings for Faint Spectra*

PROBLEMS OF THE GALAXY

J. Gallo, Tacubaya, *Star Counts on Plates of the Zonal Astrographic Catalogue*

C. Graef and F. Alva, Tonanzintla, *Application of Seares Method for Faint Stars*

M. Recillas, Tonanzintla, *Photographic Standards in Harvard C Regions*

R. H. Baker, Illinois, *Stellar Distribution in Aquila*

B. J. Bok, Harvard, *The Local System*

J. A. Pearce, Victoria, *Motions of Class B Stars*

N. U. Mayall, Lick, *Velocities of Globular Clusters*

VARIABLE STARS

S. Gaposchkin, Harvard, *Classification of Variable Stars*

C. Payne-Gaposchkin, Harvard, *Novae and Related Stars*

F. Recillas, Tonanzintla, *W Ursae Majoris Stars*

H. Swope, Harvard, *Variable Stars and the Galactic Nucleus*

TIME AND CHANGE

G. Birkhoff, Harvard, *Mathematical Concept of Time*

H. N. Russell, Princeton, *The Present State of the Theory of Stellar Evolution*

T. Sterne, Aberdeen, *Changes in Periods of Variable Stars*

A. Barajas, Mexico, *Transformations in Geometry*

M. Vallarta, M.I.T., *Emission of Charged Particles from the Sun*

R. McMath, Michigan, *Solar Prominences*

D. H. Menzel, Harvard, *The Variation of the Sun*

H. Shapley, Harvard, *Time and Change in the Metagalaxy*

GENERAL

G. Dimitroff, Harvard, *The Schmidt Astrographic Camera*

V. M. Slipher, Lowell, *Surfaces of the Major Planets*

R. McMath, Michigan, *Solar Prominences*

R. W. Wood, Hopkins, *The Growth of Crystals*

O. Struve, Yerkes, *The Cosmogonical Significance of Stellar Rotation*

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onto the older Passover date. And this, while it has connection in the Jewish religion with the bondage in Egypt, no doubt predates that and goes back to a sacrifice festival held in the spring. So all spring festivals have an astronomical origin.

The word Easter may come from the Saxon *Eostre* or *Ostara,* the Saxon goddess of spring, whose feast was celebrated every year about the same time. Others connect it with *oster,* rising. To the Christians this is interpreted as the Resurrection but it, too, may go back to the older notion of spring as the rising time of nature.

The names of the festival in other languages (French, *paques;* Italian, *pasqua;* Spanish, *pascua*) are derived from the Latin, *pascha.* This, coming through the Chaldee, is from the Hebrew name of the Passover, *pesach.*

The early Christians of Jewish descent no doubt continued to observe the old holidays, but gave them new significance. But when the number of Gentile Christians increased, a serious controversy arose as to the proper date for the celebration. The Jewish Christians, who connected the death of Christ with the Pascal Lamb, ended their fast at the same time as the Jews, on the 14th day of the moon at evening, and the Easter festival immediately followed without regard for the day of the week. The Gentile group, however, associated the first day of the week with the Resurrection, and kept the preceding Friday as the day of the Crucifixion, regardless of the day of the month.

Generally speaking, the Eastern churches followed the Jewish rule, and the Western, the Gentile. The matter was settled at the famous Council of Nicaea in 325; in fact, its consideration was one of the reasons for calling the Council. The rule is that Easter Day is always the first Sunday after the 14th day of the moon which happens upon, or next after, the 21st day of March; and if the 14th day happens upon a Sunday, Easter Day is the Sunday after.

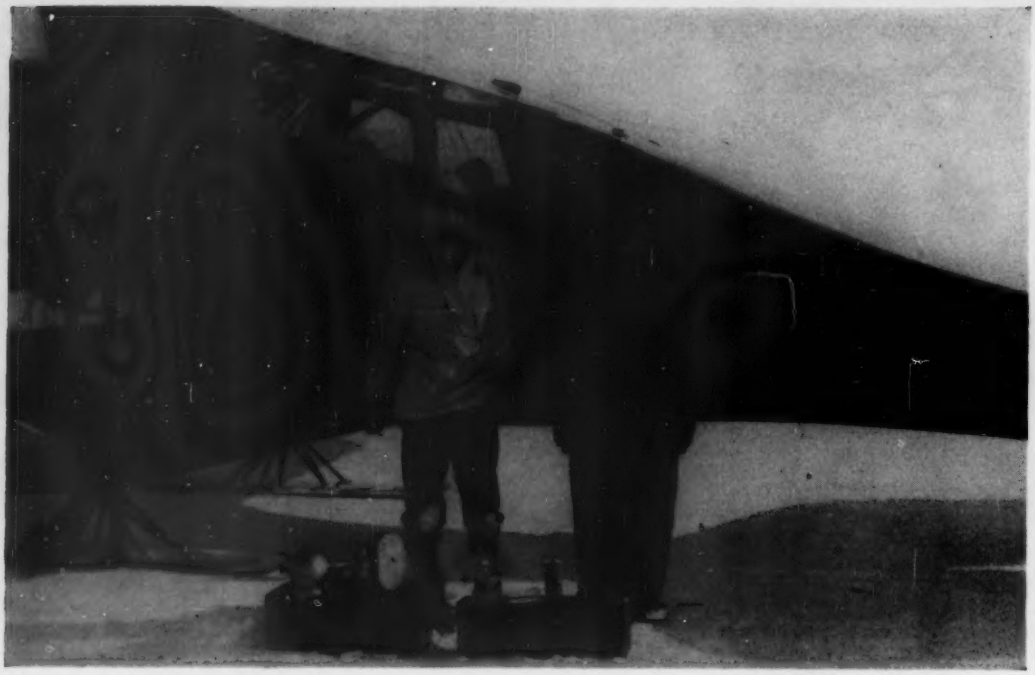
But that did not end the difficulties. Who was to tell when the full moon would come? This was referred to the Bishop at Alexandria, seat of astronomical learning in the world. The date of Easter had to be computed from the lunar cycle. But which cycle? There was a cycle of eight years, the Alexandrian cycle of 19, the Roman cycle of 84 years and one of 532 years figured out by Victorius in 457 A.D. The Roman church used the Victorian, while the English and Irish churches used the Roman cycle of 84 years. Many controversies and complications arose! There have been as many as three Easters in a year. In 387 and 577 some churches celebrated on March 21st, some on April 18th, and some on the 25th.

At present the Easter limits are March 22nd to April 25th, inclusive. Only four times since the Gregorian calendar was adopted has Easter occurred on March 22nd: 1589, 1693, 1761, 1818, and it will not occur again until 2285. Next year Easter will come at its latest date, April 25th. This occurred last in 1886 and will not happen again until 2038. This year the moon is full on April 1st, so Easter is on the 5th day of the month.

In pagan times the fourth month of the year was devoted to the goddess of spring, Eostre, hence that month was really the Easter month. Their festivals had to do with the bringing of leaves to the bare trees, and the return of life to the world. The Maypole was originally a part of such ceremonies. The mystical significance of the festival was to encourage the tree to send out leaves. By dancing in the forest, masquerading in leaves and flowers, an example was set for the trees. To us, familiar as we are with the conception of the uniformity and regularity with which the great cosmic phenomena succeed one another, there seems little ground for apprehension. But this confidence in nature is bred only by experience which comes of extensive observation and long tradition.

The succession of day and night comes so regularly and in so short a cycle that it is more easily appreciated, but even the seasonal changes come at long enough intervals that primitive man had difficulty determining the length of the cycle. Therefore a great many of his festivals come after the date of the change of season. The great clock and calendar—the sky—told him when to perform his rites. And following them came the desired result, after the winter solstice the lengthening day, and after the spring rites the budding of nature. What was once a matter of necessity, in the mind of early man, remains with us today as a pleasant memory, a tradition to be maintained and clothed with new meaning.

COSM
U.



Dana K. Bailey (*left*) and his pilot about to take off for a cosmic ray flight over Little America. Note the instruments on the ice in the foreground.

THE United States Antarctic Expedition sailed from Philadelphia on November 21, 1939. The expedition consisted of the U.S.S. *North Star* and the *Bear,* the former an Interior Department boat which during the summer was in the Alaskan service, while the latter was Admiral Byrd's personal ship which had been leased to the Navy. The expedition occupied two bases in Antarctica, one at the old site of Little America, now rechristened West Base, and the other at the new location on the Palmer Peninsula, near Margueri Bay, called East Base. The two ships carried the men and equipment for the bases, and also the dogs, airplanes, and other means of transportation which were all left on the ice for operations during the ensuing year.

The establishment of these two bases gave a unique opportunity for many types of research, and various fields of science were represented by the personnel. There were geologists, biologists, oceanographers, physiologists, meteorologists, and astronomers. The bases provided an opportunity to make observations at points quite near the south pole, and what is equally important from the point of view of cosmic rays and terrestrial magnetism, near the south magnetic pole.

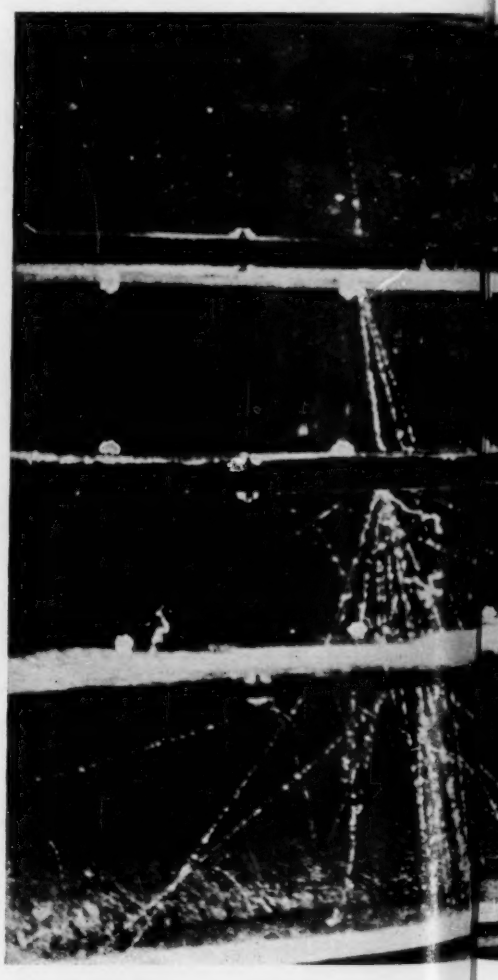
A cosmic ray program was included in the agenda of the expedition. It will be recalled that cosmic rays have made substantial contributions to knowledge, not only in the domain of high-energy physics and in the study of the rays themselves, but also in providing useful information in the fields of terrestrial magnetism and meteorology. Terrestrial magnetism has a considerable influence on cosmic rays, since these rays, being electrically charged particles, are deflected in the earth's magnetic field. The deflection takes place in such a way that only the high-energy particles can reach the surface of the earth near the equator, but all particles including those of quite low energies can reach the upper atmosphere near the poles.

This phenomenon is quite closely associated with the formation of the aurora, and indeed the same mathematical treatment describes the orbits of both cosmic rays and auroral particles. Much of the deflection of cosmic ray particles takes place at points quite distant, in fact, tens of thousands of miles from the earth's surface. Further, since the cosmic rays depend on the earth's magnetic field, we should expect that changes in that field would alter cosmic ray intensity. Such changes take place, and we call the large and irregular ones magnetic storms. It has been found that they do affect the cosmic ray intensity, and that new information regarding the nature of these storms may be gleaned from studies of the cosmic rays.

Our present picture of the cause of magnetic storms is that electrons arriving from the sun are caught in the earth's magnetic field in certain stable orbits and produce ring currents around the earth. There are many types of ring currents which would produce similar changes in the magnetic field but different changes in cosmic ray intensity. Hence the cosmic rays can help to tell us which of these ring currents are actually formed.

In the field of meteorology, cosmic rays can be of considerable use. The intensity of the rays depends on the amount of absorbing matter through which they pass, and therefore gives rise to the well-known barometric pressure coefficient. However, since the cosmic rays which reach the earth's surface are largely the secondary mesotrons which possess the curious property of disintegrating spontaneously, the number which arrive at the earth's surface (the cosmic ray intensity), depends on the length of the path which they follow while coming down from the stratosphere. Consequently, even though the pressure may remain constant, if the temperature of the atmosphere changes and the entire air mass rises somewhat by expansion, the intensity at sea level decreases because more of the cosmic rays have had time to decay on the way down. Hence, a study of cosmic ray intensity at a station at sea level gives us a picture of what is happening in the atmosphere above the cosmic ray meter. It is our expectation that cosmic ray measurements may be developed as a useful aid to meteorologists.

With these considerations in mind the cosmic ray program in Antarctica was planned to include observations which



RAY OBSERVATIONS ON THE ANTARCTIC EXPEDITION

By Serge A. Korff, *New York University*

would allow studies of the connections between cosmic rays, meteorology, and terrestrial magnetism. This included leaving two of the cosmic ray meters at West Base over the winter night in the care of some of the scientific personnel, making some flights in airplanes to determine the variation of cosmic ray intensity with height, and also conducting certain experiments on shipboard.

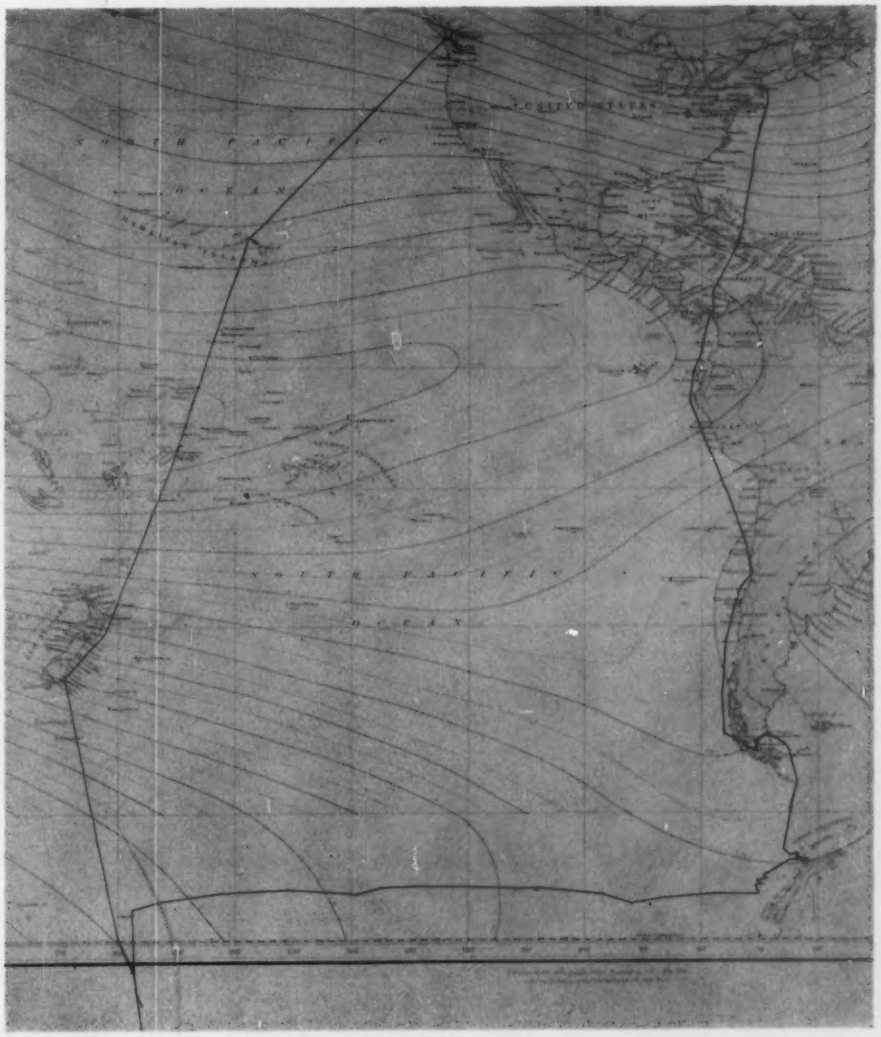
On the first trip which the *North Star* made, Eric Clarke operated the cosmic ray meters on shipboard and supervised the installation of the meters in the "science shack" at West Base. Some additional equipment was also operated on shipboard on the return. On the second trip, the purpose of which was to evacuate the personnel, Dana Bailey, a former Rhodes scholar and member of the Hayden Planetarium-Grace Eclipse Expedition to Peru in 1937, accompanied the ship to operate meters on board and to superintend the removal of the cosmic ray equipment from West Base.

He operated a neutron counter on the ship going to Antarctica, and also took this counter ashore for some runs in Hawaii and Panama. While at West Base he was able to make several airplane flights with the cosmic ray meters and also did a careful job of determining the local radioactivity and of obtaining such other data as was necessary for the interpretation of the observations. Leaving West Base, he operated the meters on shipboard returning home.

Bailey's observations and Clarke's provided two excellent runs with the same apparatus through the farthest south latitudes at which cosmic ray instruments have thus far been successfully operated. After the return of the ship, Mr. Bailey was able to remain at the Bartol Research Foundation at Swarthmore as a physicist of the United States Antarctic Service, where he superintended the computation of the results. In this he was assisted by Ernest K. Smith, of Swarthmore College, for which assistance the American Philosophical Society generously made a grant.

This cosmic ray program is an excellent example of the type of work that can be accomplished through cooperation. We are indebted to many persons, organizations, and commercial companies for their assistance. It is particularly gratifying to acknowledge the invaluable assistance received, often at considerable personal inconvenience, from the scientific personnel of the U. S. Antarctic Service. This work has resulted in obtaining data which will be published in full in the near future in the research journals, and which it is hoped will contribute in some small measure to our understanding of the interesting connections between cosmic rays, terrestrial magnetism, and meteorology, as well as throwing further light on the nature and properties of the rays themselves.

Left: **With a cloud chamber in the laboratory, cosmic ray tracks can be photographed and studied under varying conditions. The horizontal lines are lead plates through which the rays must pass.**



Right: **Route of the U.S.S. *North Star* on the voyage to Antarctica during 1940-41. Cosmic ray observations were made on board the ship, which touched at both Bases.**

AMERICAN ASTRONOMERS REPORT

Further papers from the American Astronomical Society meeting in December are summarized by the Editors.

Star Shells and Spectra; Pleione

SEVERAL papers discussed stellar spectra in detail, and two from Yerkes Observatory were concerned with stars having extended shells of gas as their outermost atmospheres. In discussing departures from thermodynamic equilibrium in extended atmospheres, Dr. Otto Struve said that the gaseous shells of certain stars often extend so far above the photosphere that the application of Boltzmann's formula for excitation of atoms and Saha's formula for ionization of atoms is not even approximately correct.

Dr. Struve said it is now possible to attack the important problem of the effect of the energy distribution of the star's continuous spectrum upon the intensities of lines produced in the shell, and he discussed the shells of 14 Comae and HD 190073, which have very weak Balmer (hydrogen) lines. He said that Lyman (ultraviolet) absorption in the reversing layer of the star apparently caused depletion of energy in precisely those frequencies which are required to produce excitation of the second level of hydrogen (Balmer) in the shell.

Other Yerkes investigators, M. Kiess, W. Krogdahl, W. Bidelman, and R. G. Hall, reported on changes in the spectrum of the star called Pleione (28 Tauri), which has a shell discovered in 1938 by McLaughlin and Mohler. New plates taken at Yerkes and McDonald Observatories in October and November, 1941, show a spectrum which at first sight looks like a replica of Deneb's (α Cygni), but quite different from that observed a year ago. There has been a conspicuous enhancement of nearly all lines, which probably has progressed gradually since 1938. However, Mg II and Si II lines have not changed appreciably.

Pleione now exhibits the most conspicuous shell spectrum ever observed in any star not known to be a nova or a nova-like object. Were it not for the weakness of Mg II and Si II, and for its known parallax, we should classify it among the supergiants. Accurate observations of the brightness and energy distribution would be of use in the interpretation of this remarkable star.

Sirius and Alhena

THE *curve of growth* relates the intensity of a spectral line to the number of atoms acting to produce it. From the observed line intensities, and the pressures and temperatures in the atmosphere of a star, we try to find the total number of atoms above the photosphere, that is, above the luminous surface of a star. L. H. Aller, of Harvard College Observatory, reported the results of measurements of the intensities of several hundred lines in the spectra of Sirius and Alhena (γ Geminorum), analyzed by means of the curve of growth.

These two stars are of spectral type *A*, and this analysis shows them to have atmospheres about 10 or 20 times as hazy or opaque as that of the sun, due to hydrogen in each case. In hotter stars atomic hydrogen is responsible for the increased absorption; in cooler ones the atoms attach to themselves negative electrons and continue to be voracious absorbers of radiation.

Another result of this study is an estimate of the ratio of abundances of hydrogen and iron. By weight, there is about 1,000 times as much hydrogen as iron per unit volume in the atmospheres of Sirius and Alhena. If 13 per cent of all metal atoms are iron atoms, the ratio of the total number of hydrogen atoms to the total number of metal atoms is about 7,000 to one. If only four per cent are iron atoms, the hydrogen-metal ratio is about 2,000. In any case, the evidence for a very large amount of hydrogen as compared with the metals is strong.

Distant Red Giants

GIANT red stars may be used to determine distances in the galaxy, according to a paper presented by Dr. Dorrit Hoffleit, of Harvard College Observatory. In her work, she considered the spectra of some 300 red giant stars in both northern and southern hemispheres, and came to the conclusion that in general the normal giant *M* stars are all of about the same intrinsic brightness, so that they may be used as celestial measuring rods.

In 1935, Mt. Wilson Observatory published the real brightnesses and distances of all stars except the very blue ones in the northern hemisphere, and brighter than magnitude 6.5, the limit of naked-eye visibility. Harvard has carried on a similar study in the southern hemisphere, but in the case of *M* stars, marked disagreements among the results obtained at different observatories led Dr. Hoffleit to include both hemispheres in her work.

The distances and brightnesses are determined by the spectroscopic method, based on studies of relative intensities of lines in stellar spectra. The original relation between the intensity of a certain line and a star's absolute magnitude is ordinarily ascertained from nearby stars whose distances are well known from the trigonometric method. Among the giant red stars, however, too few are sufficiently nearby for calibration purposes, so an alternative method makes use of the fact that nearby stars, on the whole, change their places in the sky faster than those which are farther away.

This *proper motion* effect shows the average red giant star to be about 100 times as bright as the sun. The individual dispersions away from this average are smaller than for giant stars of other colors, so Dr. Hoffleit suggests that for most purposes, such as the study of the structure of the galaxy, a particular *M* giant can be considered to be as bright as the average for its class. This is in general agreement with the result of an investigation by Stromberg at Mt. Wilson in 1927. When applied, it can save the time and labor of determining individual magnitudes of *M* giant stars.

Dominion Astrophysical Reports

THREE papers were read from astronomers at the Dominion Astrophysical Observatory, Victoria, B. C., indicating that Canada's war effort has not prevented continued research at that institution. The first was by Dr. C. S. Beals, on the variable spectrum of the star HD 190073, the same star investigated by Dr. Struve, and mentioned in his paper on star shells. Dr. Beals finds the star surrounded by an expanding envelope, the atoms of which appear to receive a large initial impulse when being ejected from the star, and are subsequently slowed down by the gravitational field to a velocity which approaches zero at great distances from the star. Calcium absorption appears to take place at a distance of 1,000 times the radius of the star itself.

Dr. J. A. Pearce described the massive eclipsing binary star, HD 227696, which has the unusual mass of 30 times the sun's (for the system). He stressed the accuracy of the spectrographic results obtained. The distance of the star is 3,900 light-years. Twenty-five plates were secured in 61 days with the 72-inch reflector at Victoria —it is important, where the orbit is probably rotating, to obtain accurate spectrographic elements on a short base line. Dr. Pearce wrote that computers who give elements for *B* stars from observations secured over an interval of many years fail to find the small changes in the elements. The luminosities of the components of HD 227696 are 6,400 and 4,000 times the sun, and their respective masses at least 17 and 13 times the sun's. Their spectra appear to be identical. Joseph Ashbrook,

of Harvard College Observatory, using 1,100 plates, is working on a photometric orbit for this star.

The third paper from Victoria was by W. H. Stillwell, on the spectroscopic binary HD 34762, and gave the results of 70 observations since 1936. The period of the binary is 5 days, 10 hours, 24 minutes, and its components are separated by about 2½ million miles.

Standard Lamp Energy Distribution

BY comparison of spectrum-plate densities of celestial objects with similar spectrum photographs of a standard lamp of known spectral energy distribution, the astronomer is able to obtain the distribution of energy in the spectrum of an unknown source. In recent years the G. E. Mazda tungsten ribbon lamp in a glass bulb, with a quartz glass window, has been used as a standard source for this purpose. Dr. W. W. Coblentz reported on tests made at the U. S. Bureau of Standards to determine the validity of published data on spectral emissivity. He found that the data published by Hoffmann and Willenberg is the most accurate now available.

Spurious Spectral Bands

ALONG these same lines, Dr. W. A. Hiltner and R. G. Fowler, of the University of Michigan Observatory, discussed large irregularities in the wavelength sensitization of the Eastman 103-F emulsion. They reported that several spurious bands had appeared in the 103-F emulsion at 5300 A and 5700 A, which had caused some confusion in astronomical spectroscopy. For instance, Humason and Minkowski, at Mt. Wilson, reported bands present in a supernova at these wave lengths, but later identified them as due to sensitization bands in the 103-F emulsion.

Eclipsing Binaries

DR. ZDENEK KOPAL, of Harvard College Observatory, said that hitherto most attention had been paid to the fluctuations in the brightness of eclipsing double stars between times of minimum brightness, and that from such studies the departures of both components from a spherical form are well understood. However, corresponding changes of light within minima (while the eclipses are taking place) have not been hitherto very completely studied.

Two important factors are concerned with changes in the light during an eclipse, Dr. Kopal said: 1. Difference in the amount of flattening at the poles of the two component stars. 2. Variations in brightness in various parts of the eclipsed star, due to the effect of gravitation. The first is not likely to be important unless the two stars differ greatly in form. The second is likely to be a dominant factor in determining the light changes which will be observed.

DO YOU KNOW?

By L. J. Lafleur

I. Score four points for each question correctly answered, and one point for each question where you do not attempt to select the answer.

1. One of the following constellations does not contain part of the Milky Way:
   a. Crux c. Musca
   b. Centaurus d. Columba
2. A "black body," in astronomy, is
   a. a perfect radiator
   b. a light-absorbing medium
   c. an infrared star
   d. a dark star
3. Approximately how much of the moon's surface is invisible?
   a. 1/3 c. 1/2
   b. 2/5 d. 3/5
4. The length of a degree of latitude at the poles is about
   a. 68.7 miles c. 76.3 miles
   b. 73.6 miles d. 86.4 miles
5. One of the following constellations lies on the ecliptic:
   a. Ursa Major c. Taurus
   b. Orion d. Pegasus
6. A millionth of a millimeter is indicated by the symbol
   a. λ c. μ
   b. λλ d. μμ
7. A focal-plane reticle is used in observing
   a. albedo c. occultation
   b. Gegenschein d. transit
8. Tidal evolution occurs only with bodies that are
   a. gaseous c. viscous
   b. liquid d. elastic
9. The Fraunhofer lines are
   a. lines of force in a magnetic field
   b. lines observed on Mars during a near approach
   c. lines in a spectrum
   d. lines of energy transmission
10. One of the following is not the brightest star in its constellation:
    a. Alpha Ursae Minoris
    b. Alpha Virginis
    c. Alpha Orionis
    d. Alpha Coronae Borealis

II. The following statement is adapted from Jeans. Count two points for each word de-anagrammed. Blanks indicate words that have already appeared in the statement.

Let us, in AAIIIOGMNNT, keep a IUBCC EEIILLMMRT of AIOYDNRR AEMRTT at a AEEEUMPRRTT of IYFFT IIOLLMN EEESGRD, the AAEIOMPPRTX——at the EECNTR of the sun. EEIIBCDLNR OUTHHG it may seem, EEYLMR to AAIIMNNT this AEIDHNP of —— at such a ——, i.e., to EEIHLNPRS the EEYGNR it EOLSS by AAIIODNRT from its six AECFS, OUDLW EEIUQRR EEHRT AIIOUDLLNQR EEOOPHRRSW; the —— of —— —— kill AEOYNN who EEUDNRTV IIHNTW a AOUDHNST miles of it.

(*Answers on page* 23)

Allegheny Parallaxes

SINCE 1914, nearly 63,000 plates of stars have been taken in the parallax program of the Allegheny Observatory in Pittsburgh, according to Zaccheus Daniel. He said that about 500 stars are constantly on the observing list, and more than 2,100 stars have been under observation, and 1,607 have been measured and computed—more than by any other observatory using the same method.

In stellar parallax work at Allegheny, each result depends upon the measurement of about 30 plates with three exposures of three minutes or more each. The parallaxes are taken relative to faint comparison stars, and the results are very accurate, due to the efficiency of the 30-inch Thaw refractor. The latest and most noteworthy parallax obtained is that for the star Procyon, which is just 11 light-years away.

The late Dr. Frank C. Jordan was an assiduous observer of parallaxes during the many years he was director of Allegheny Observatory.

Corrections to February Issue

"Do You Know?" I, 6, d, should read: "*shorter* than any except Mercury and Venus," which is the correct answer.

In "Waves from Space," page 5, column 2, lines 7-8, should read: "which causes the star to appear a little *higher* in the sky."

On page 11, Figures 2 and 4 are reversed.

Astronomical and Astrophysical Instruments

ROSS LENSES

SPECIAL LENSES, MIRRORS and PRISMS, of all sizes

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Amateur Astronomers

PONTIAC A. A. RATIFIES BY-LAWS

The tenth society to ratify the by-laws or propose conditions necessary for final ratification of membership in the Amateur Astronomers League of America is the Pontiac (Michigan) Amateur Astronomers Association.

Secretary John P. Coder says in his letter containing the above information that "our group is very glad to have the opportunity of associating itself with sister organizations throughout the country and wishes you speedy success with the final details. We would also like to state that we intend to cooperate in any way we can with the Detroit clubs in sponsoring the convention this summer. We are especially well situated to work with the Cranbrook Institute of Science and the McMath-Hulbert Observatory in arranging for visits by the convention if these are desired. Both these institutions are within five miles of Pontiac."

PHILADELPHIA COMMITTEE CEASES ACTIVITIES

On February 2nd, the work of the Committee on Education and Participation in Science was terminated. This action was caused by the entry into the Army of W. Stephen Thomas, executive secretary.

The office of the committee has been closed, and inquiries concerning the research projects for amateurs should be referred to the individual consultants:

Zoology—Roger Conant, Philadelphia Zoo.

Botany—Dr. John M. Fogg, Jr., University of Pennsylvania.

Physics and Astronomy—Dr. Serge A. Korff, New York University.

General Science, Tree Rings and Climatology: Dr. Edward E. Wildman, 4331 Osage Ave., Philadelphia.

A notable result of the committee's efforts in promoting adult and amateur science in the Philadelphia area was the organization early in 1940 of the Philadelphia Council of Amateur Scientists, with 22 affiliated groups. John T. McNeill, Jr., 800 West Fisher's Ave., Philadelphia, is president of the council.

DETROIT A. S.

The annual business meeting and election of officers of the Detroit Astronomical Society was held at Wayne University in January. New officers are Cornelius W. Spain, president; E. G. Brown, vice-president; Marvin Vann, treasurer; and Mrs. Margaret Back, reelected secretary.

In retiring, after two years as president and two as secretary, Claude B. Carpenter, A.A.V.S.O., gave an instructive talk on his experiences in astrophotography, illustrated by his own enlargements of star clusters and the nearer nebulae. Mr. Carpenter gave detailed accounts of his varied experiments with plates, emulsions, and filters.

It was suggested that a profitable and interesting session might be devoted to an exchange of similar experiences by amateurs at the convention in Detroit next July.

LETTER TO THE EDITOR:

Many thanks for your information. . . . (It) induced me to submit a little report—I know without any scientific value, but maybe of interest to amateurs—covering some observations during the last months.

The first part contains a list of only a few of observed test double stars, and so forth, and I consider that the instrument, a 6½-inch Newtonian, is good and without defects. What happened is that months ago I observed objects too close to the horizon, separation of even easy doubles being impossible, due to the boiling air.

I also made a provisional micrometer (360° circle attached to the focusing eyepiece and a cross wire with index in a 150x eyepiece). . . . The second part refers to an examination of position angle (p) and distance (d) of the double star, Beta Capricorni, made with this provisional accessory. To investigate this difference in d (see report), especially to find out if the watch marked time exactly (Edox Crono, nothing special), I tried to get the diameter of Mars with the following result:

> September 17, 1941: The planet crossed the wire eight times, needing 12 seconds from east to west, so its diameter is 12×15/8 or 22".5, which checks very well with 22".7 given in The SKY for September, 1941.

The last part consists of six drawings[1] (one in water color) of Mars. I have no astronomical ephemeris here, which would permit me to know the central meridian of Mars during these observations, so I cannot say if the drawings are correct. (This may be better for impartial observing). . . . No filter or dark glass was used. . . .

. . . Please let me know your opinion about my little report and any suggestion you consider convenient, I being interested specially in double stars, planets, and the moon.

R. STUEMPFLE
Trujillo, Peru

Pataz, October 10, 1941.

[1]To be published next month in an article on observations of Mars.

1. Test objects observed with 6½-inch Newtonian:

Object	*Magnitudes*	*d*	*Remarks*
ϵ Centauri	2.6—7.9	2".8	Difficult.
μ Librae	5.4—6.6	1".6	
NGC 4594 (Virgo)			Cigar-shaped spiral, not easily found.
ζ Ophiuchi	4.7—6.2	3"	Very sharp with 100x.
NGC 7009 (Aquarius)			"Saturn nebula." Resists power up to 250x; like a star out of focus.
5 Serpentis	5.2—10.0	10"	Difficult; close to the beautiful cluster M 5.
τ Ophiuchi	5.1—6.0	1".3	250x.
γ Piscis Aus.	4.5—8.8	4"	
NGC 221 (M 32)			Companion to the large Andromeda spiral nebula.
η Sagittarii	3.4—10.3	3".7	Very difficult; fainter star nearly disappears in light of brighter one.
ϵ^1 Lyrae	5.0—6.3	3".2	The "double double," clearly separated with 100x.
ϵ^2 Lyrae	4.9—5.2	2".3	

2. Beta Capricorni: Position 1900 (Stuker) 20h 15.4m —15° 6'
p 267° d 205" Corrected to 1940 20h 17.7m —15°13'

Observed in four nights as follows:

Aug. 23, 1941	p 265°	t 13.6 sec.	(t is average of four "transits" per night)
Aug. 30, 1941	270°	13.45	
Sept. 3, 1941	269°	13.55	
Sept. 5, 1941	268°	13.65	
Average	268°	13.56 sec. × 15 = 203".4 = T	

$$d = T \times \cos \text{dec.}/\sin p = \log^{-1} 2.2931044 = 196''$$

To get 205", t has to be about ½ second more. This "mistake" I consider too big taking the average of 16 times the star's crossing the wire. Either the watch used is not exact or the component of Beta Capricorni has a proper motion, at least in d.

AMATEUR ASTRONOMERS ASSOCIATION
New York City

Lectures: March 4—*The Nearest Stars*, by Dr. Peter van de Kamp, Sproul Observatory, Swarthmore, Pa. This will be a non-technical survey of the nearer stellar systems.

March 18—*Those Pulsating Cepheids*, by Dr. Martin Schwarzschild, Rutherfurd Observatory, Columbia University. The talk is on latest theories concerning this famous class of variable stars.

Guest tickets are available for each of these lectures, which are open to the public. Meetings begin at 8:15 p.m., in the Lecture Hall of the Roosevelt Memorial, American Museum of Natural History, New York City.

Classes: Astronomy, constellation study, physics, and mathematics are studied in classes conducted by the association. Write for the folder *Enjoy the Stars* for full details and membership application.

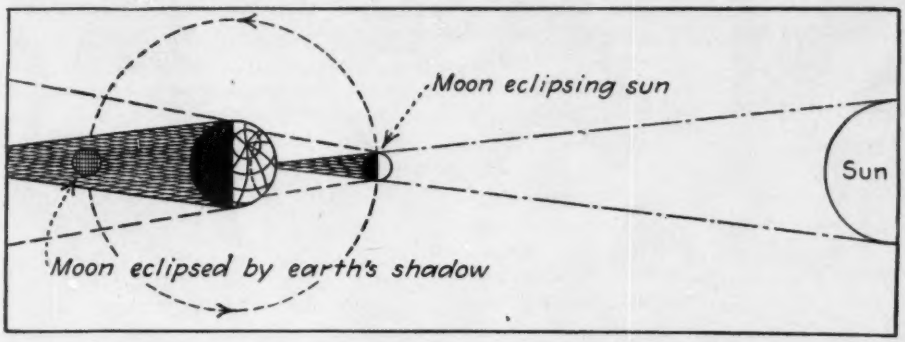
Lunar Eclipse Expedition: Members of the association will form an expedition to observe and photograph the total lunar eclipse of March 2nd. Cameras and telescopes will be set up at a suitable location near Westbury, Long Island. The program of observations is under the direction of Peter A. Leavens.

BEGINNER'S PAGE

By Percy W. Witherell

THE ECLIPSE OF THE MOON

As the moon rises over the New England coast on March 2, 1942, it will appear a little less bright than usual because it will already be immersed in the penumbra of the earth's shadow (see cone of dashes at left of the earth in drawing). A little later, as the moon moves into the principal shadow (umbra) of the earth (see shaded cone on the left of the earth), a dark segment of a circle appears on the moon's surface, which increases in area until the entire moon is covered. As we know that the earth is rotating on its axis, this round shadow of the earth is evidence that our planet is a sphere, because no rotating solid of any other shape could cast a circular shadow. The axis of this shadow is always projected to a point directly opposite to the direction of the sun.



On March 2nd, the full moon will enter the earth's shadow and be eclipsed; on the 16th, the new moon will cast its shadow on the earth and cause a partial eclipse of the sun, which will be visible only in the southern Pacific Ocean. The diagram is not to scale.

If the path of the moon around the earth were exactly in the plane of the ecliptic and the distances of the sun and moon from the earth remained constant at about their average number of miles, there would be an eclipse of the moon every time it was full. Fortunately for the lover, poet, and astronomer, this is not true, so that a lunar eclipse occurs usually twice a year. If one happens near the first of January, it is possible to have three. Some years there are none.

The plane of the moon's orbit around the earth is inclined about 5¼ degrees to the ecliptic, so that our satellite usually passes either north or south of the earth's shadow. When the moon crosses the ecliptic (at one of the nodes), if the moon is full there is an eclipse of the moon; if this happens at new moon, there is an eclipse of the sun. If the moon passes directly through the shadow, there occurs a total eclipse of the moon; if through only a portion, a partial eclipse is the result.

The length of the cone of the earth's shadow is about 857,000 miles, but this may be as much as 14,000 miles more or less. The moon is moving 2,100 miles per hour along its orbit. On the average, the cross-section of the shadow where the moon is obscured is 5,700 miles, or about 2⅔ times the diameter of the moon, so that it takes several hours for the moon to pass through both the umbra and penumbra.

Usually the moon appears copper-colored during totality. This is due to the rays of the sun passing through the lower layers of the earth's atmosphere and being refracted to the moon's surface, and then reflected to the earth. As the light travels twice as far through the air as it does at sunset, the reddening effect is doubled. From the moon, the earth would be seen with a colored ring of bright sunshine surrounding it. Sometimes, when it is very hazy along the twilight circumference of the earth, so that no rays penetrate the earth's atmosphere, the moon is invisible at totality, as in 1884.

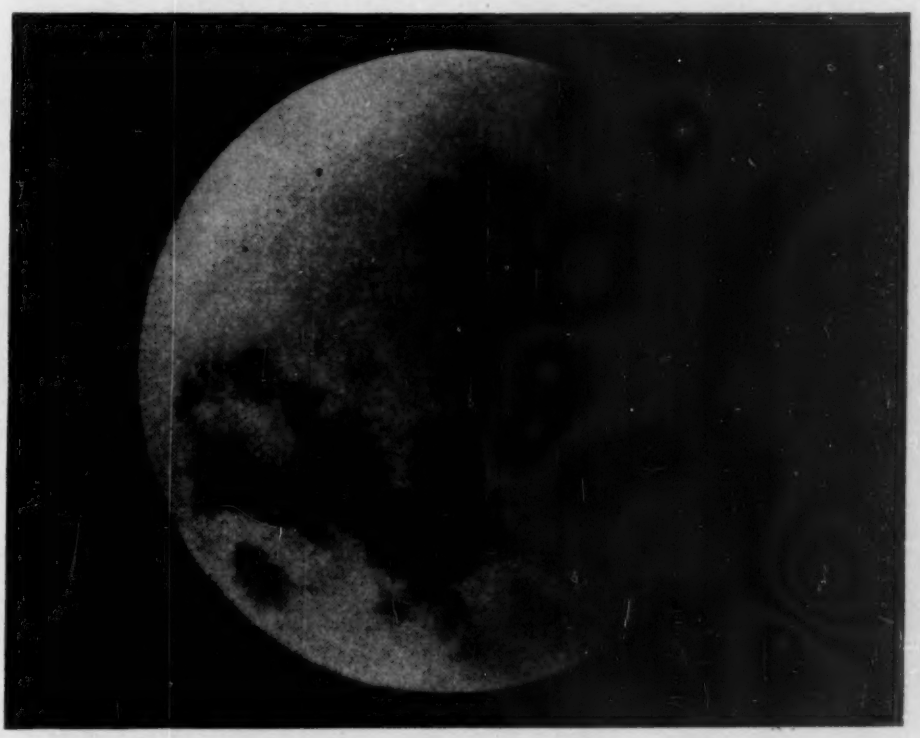
As an eclipse of the moon is usually visible to half of the earth, a single calculation gives the times of contact at Greenwich, from which it is easy to find the local times of the event (see *Sky and Telescope*, February, 1942).

As eclipses were considered omens of fate, they were carefully recorded in relation to other important historical events. This has been of value in correlating ancient dates with our modern calendars, because if the place is known, the time can be calculated when an eclipse must have occurred at that particular site.

A comparison of the recorded times of ancient eclipses with times calculated from modern observations shows that the rotation of the earth is slowing down on account of the braking effects of the tidal friction. However, as this amounts to only 1/1,000 of a second in 100 years, no immediate adjustment of clocks is necessary!

Observations of occultations of very faint stars during an eclipse give more exact data on the diameter, mass, distance, and orbit of our satellite. During a total eclipse, the study with the spectroscope of light reflected from the moon enables the astronomer to study the composition of the atmosphere of the earth. Any difference between the sun's light as ordinarily reflected from the moon's surface and that seen during an eclipse would be due to the effect of the longer path that the rays had traveled through the atmosphere of the earth during the event. Also data on the temperature and absorbing power of the moon's surface may be obtained.

In 1942 we will have another total eclipse of the moon on August 26th, and three partial eclipses of the sun, on March 16th, August 12th, and September 10th. None of those of the sun will be visible in the United States.



The shadow of the earth on the moon is always curved, as shown in this photograph of the partial phase of a lunar eclipse.

GLEANINGS FOR A. T. M.s

EDITED BY EARLE B. BROWN

THE GAVIOLA OR "CAUSTIC" TEST—III

CURVE-FITTING

AFTER a Gaviola test has been performed upon a mirror, and the data tabulated, the problem arises of finding a parabola which is nearer, on the average, to the actual curve on the mirror than any other parabola, and then determining whether the deviations from this "best-fit" parabola are tolerable. This is a mathematical problem of frequent occurrence in scientific work, and while it sometimes becomes a problem of considerable complexity, it is possible to give a rule-of-thumb method for solving the particular case of the evolute to the parabola posed by the Gaviola test.

We are given the parametric equations of the evolute (see January issue):

$$A = \frac{3r^2}{2R} \qquad B = -\frac{r^3}{R^2} \qquad (4)$$

and we have the following data to work with:

1. The measured B's, which we shall call b_1, b_2, etc.
2. The values of r corresponding to each measurement.
3. The values of A corresponding to each measurement.
4. The value, d, of the zone breadth.

We begin by setting up a sheet with columns as follows:

Col. 1: values of r
Col. 2: values of r^3
Col. 3: values of b
Col. 4: corrected values of B
Col. 5: deviations—B'
Col. 6: deviations of mirror surface—h

Columns 1 and 3 are filled in from the known data. Column 2 is computed from Column 1, by cubing each r. Now, we add Columns 2 and 3, divide the total of Column 2 by the total of Column 3, and take the square root of the quotient. This is the value of R for the parabola of best fit. The best focal length of the mirror is therefore one half of the new R.

Column 4 is filled in by computing new values for B, using the new value of R in equation (4). Column 5 is Column 3 minus Column 4. Column 6 is computed from Column 5 according to the equation

$$h = B' \frac{d}{R}, \qquad (5)$$

the total of Column 6 being obtained and divided by the number of items to obtain the average deviation of the mirror surface from the parabola of best fit. The Gaviola test is capable of making measurements which will determine this deviation down to .0000002 of an inch, or 1/100 of a wave length of light. A deviation 10 times greater than this is quite tolerable. The degree of precision to which a mirror surface is figured depends, of course, on the conscientiousness of the maker, but it would seem futile to try to carry the process beyond the point of practical significance. It is conceivable that, given a mechanical construction of extremely high precision, and a desire to do careful quantitative work, a deviation of the mirror surface from perfection of 1/10 of a wave length might be considered a maximum tolerance. But two or three times this value would be of no significance in ordinary observing, and might be completely overshadowed by mechanical imperfections.

Illustrative Example:

Let us suppose a hypothetical case of a 10-inch f/5 mirror (R = 100", d = ½") and measured b's according to Column 3 below. Then our tabulation is as follows:

Column 1 r	*Column 2* r^3	*Column 3* b	*Column 4* corr. B	*Column 5* B'	*Column 6* h
.5 inches	.125	.0000	.0000	.0000	.0000000
1.0	1.000	.0001	.0001	.0000	.0000000
1.5	3.375	.0003	.0003	.0000	.0000000
2.0	8.000	.0007	.0008	—.0001	—.0000005
2.5	15.625	.0015	.0015	.0000	.0000000
3.0	27.000	.0028	.0026	.0002	.0000010
3.5	42.875	.0040	.0042	—.0002	—.0000010
4.0	64.000	.0061	.0062	—.0001	—.0000005
4.5	91.125	.0090	.0088	.0002	.0000010
5.0	125.000	.0122	.0121	.0001	.0000005
	378.125	.0367			10/.0000005
					.00000005

Now Column 2 divided by Column 3 gives 10,303.133, and the square root of this is 101.504.

We see that the focal length at which the mirror will give best performance is ¾ of an inch greater than the true radius of curvature of the center zone; further, that the average deviation is only 1/400 of a wave length, and the greatest deviation over any ½-inch zone is but 1/20 of a wave length—quite inappreciable values. On the basis of the original theoretical parabola, however, the average deviation would be 1/40 of a wave length, and individual zonal deviations would be as great as 8/100 of a wave length. These would also be insignificant, but are considerably greater than the results from the best-fit parabola.

NOTE: The method of curve-fitting given above in a rule-of-thumb manner is known in statistics as the method of moments. It is, in this case, exactly equivalent to the method of least squares, but since the latter usually involves partial differentiation, the method of moments is more understandable to those whose mathematical training is incomplete.

The premise involved is that each moment of the curve of best-fit, the theoretical curve, is equal to each moment of the data. The **n**th moment of the curve $y = f(x)$ is defined as the summation of $x_i^n y_i$ from i = 1 to **N**. Hence, the **o**th moment is the summation of $x_i^o y_i$, or merely the summation of y, the first moment is the summation of xy, the second moment is the summation of x^2y, etc. Each moment serves to determine the value of one arbitrary constant in the equation of the theoretical curve, and we need use only as many applications of the method as there are arbitrary constants in the equation. We must, of course, decide in advance just what form the theoretical equation shall take.

In the case of the Gaviola test, we have the parabola $r^2 = 2R(x + h)$ and the parametric equations of the evolute,

$$A = 3r^2/2R - h \qquad B = -r^3/R^2$$

and our data consists of the measured B's, b_1, b_2, etc. It will be noted that the equation of the parabola has been generalized by the addition of h, which merely means that the vertex of the new curve may not be at the origin. Now, this is unimportant to us, and if we can determine the new value of the constant R we have all that we need. We need not fit the parabola directly, but can determine R by fitting the evolute to the data according to the equation $B = -r^3/R^2$. Since there is only one arbitrary constant to determine, namely, R, we need only use the **o**th moment. This is simply the summation of r^3/R^2 for the theoretical curve, and the summation of b for the data. Equating these, we have

$$\frac{1}{R^2} \text{ times the sum of } r_i^3 = \text{sum of } b_i$$

Now, the sum of r_i^3 is the total of Column 2, and the sum of b_i is the total of Column 3, hence the result:

Column 2 divided by Column 3 = R^2.

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ASTRONOMICAL ANECDOTES

EARLY TELESCOPE MAKERS AND A HEADLAMP LENS

LITTLE by little historical astronomy makes progress. In a so-called "popular" astronomy magazine such as *Sky and Telescope,* a few years ago there would have appeared some hazy statement trying to over-glorify Galileo for his independent construction of a telescope, whereas the leading article in the January issue puts the story correctly, when Galileo himself is quoted as having told that he heard about a telescope made by a Dutchman, and decided to try his hand at one, guided by his knowledge of optics. But who did make the first telescope?

The oft-mentioned legend to the effect that Roger Bacon (c. 1214-c. 1294) possessed a telescope may be just "one of those things," but it must have been discussed in some detail somewhere, or it would not keep cropping up. Such suggestions occasionally may be expected to arise because of some kind of wishful thinking on the part of some author; our modern pulp magazines with their amazing stories may provide historians of the future with ideas that rocket ships were invented and in constant use early in the 20th century, although there is a possibility that a Dutchman, one Hans Pfaal, may have had one much earlier!

Peter Borel, who wrote *De vero Telescopii Inventore,* suggests that a spectacle maker named Zacharias Janssen, about 1590, was imitated by Jan (or Hans) Lippershey (or Lippersheim) of Middlebourg, Zealand. James Metius, Hardy, and Leonard Digges (c. 1553) are supposed to have written of telescopes as though they were familiar with them. Francesco Fontana claimed credit for it, in his *Novae Coelestium Terrestriumque Rerum Observationes* (1646), in which he includes an engraving of his very sour countenance, surrounded by a legend reading thus: "Franciscus Fontana . . . Novi Optici Tubi Astronomici Inventor An. Dom. MDCVIII Aet. Suae 16." He thus claimed that he had used a telescope in 1608; he claimed further that he had invented the microscope in 1618, apparently not knowing that the above-mentioned Janssen is given credit for having made a microscope about 1590.

Giovanni Battista della Porta, a Neapolitan, wrote in his *Magiae Naturalis* (1589) in such a way that he has often been credited with having invented not only the camera obscura with a lens, and the magic lantern, but also the telescope: "Si utramque (lentem concavam et convexam) rectere componere moveris, et longinqua et proxima majora et clara videbis." It seems to be a query, "whether if one assembles correctly a convex and a concave lens, one might not see objects, near and far, larger and clear." In the same footnote where this appeared (in *Memoir of the Life of David Rittenhouse,* by William Barton, M.A., Philadelphia, 1813), is one of those exasperating statements: "and he is said to have made a telescope, accordingly, about the year 1594." Who says these things of which we say, "it is said"?

The name of the first American maker of telescopes is probably not too well known. I believe it was Amasa Holcomb, a surveyor of Southwick, Mass., who began in 1826 to make small refractors and afterward made reflectors of the Herschelian type, as large as 10 inches aperture, and to the total number of about 30. His serviceable mounting received a Franklin Institute medal in 1835. At about the same time E. P. Mason, of Yale, and Prof. H. L. Smith, of Hobart, were contemplating the 12-inch reflector they completed in 1838, which was at the time the largest telescope in America. Todd's *Stars and Telescopes* tells us thus briefly of these gentlemen; more I have not been able to find, except that I have verified Holcomb's 1835 award. Todd reminds us, too, that it was Henry Draper who improved the Newtonian telescope by introducing the idea of a totally-reflecting prism to replace the secondary mirror.

In the "Gleanings" section of *Sky and Telescope* for November, 1941, the welcome (but too brief) account of Henry Fitz brings to mind an interesting story which comes to us through the courtesy of B. L. Harrell, of Gadsden, Ala. In 1849, Fitz made a 5.6-inch refractor at a cost of $1,050, for Erskine College, at (of all things!) Due West Corner, S. C. Sometime or other the telescope fell into disuse, and the lens disappeared until recently, when an ardent amateur astronomer, the Hon. Robert H. McAdams, saw a negro walking along the street of D.W.C., carrying the lens, which he intended to use as a replacement for a broken headlamp on his car. McAdams was not able to get a satisfactory story of the original disappearance of the lens and its subsequent wanderings, but he did manage to buy it for 50 cents. It has now been put into the keeping of another amateur, Gilbert G. Pike, of Columbia, S. C., who last summer restored the original Fitz telescope, with the original lens, and has it in operation in his private-public observatory.

I believe astronomy produces more heroes than the fields of battle. One of them was certainly Hiram Mills Perkins, the magnificent old teacher who made the Perkins Observatory, at Delaware, Ohio, a possibility. He taught geometry, among other things, and for three successive days asked a student named Starr to demonstrate a proposition at the blackboard. Thrice unprepared, the student must have at last decided that he would have to weaken, and on the fourth day it was obvious to Prof. Perkins that the boy was confident. When his turn came, Prof. Perkins turned to him and quietly remarked, "Now, Starr, scintillate!"

R.K.M.

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BOOKS AND THE SKY

DOCTOR WOOD

Modern Wizard of the Laboratory

WILLIAM SEABROOK. Harcourt, Brace & Co., New York, 1941. 335 pages. $3.75.

ROBERT W. WOOD, Johns Hopkins physicist, is well on the way to becoming a great American legend—a legend in only one sense, however, for at 73, Wood is still young in spirit and as full as ever of scientific fire.

Though officially retired three years ago, Wood has continued his work, largely for the benefit of astronomers, experimenting with diffraction gratings for stellar spectra. When someone asks, "Have you heard R. W.'s latest?" you may learn either of some brilliant scientific discovery, or of some new prank that Wood has thought up. For Wood makes his science do double duty. It may be practical, but it must always be amusing.

William Seabrook, Wood's biographer, has carried out his task brilliantly. The book is human and swift-moving; it portrays Wood, the man and the scientist, most sympathetically. We see Robert Wood as a person who carried both the curiosity and the prankishness of the small boy into his laboratory. Who but he would have sent the family cat through his telescope tube to remove accumulated cobwebs? Only Wood could have suggested that seals might be trained to flush and chase submarines—an idea that was investigated by the British during the first World War. Although the seals did learn to trail oil and follow the sound of propellers, their tendency, despite their being muzzled, to run after herring schools somewhat lessened their usefulness as U-boat detectors.

Wood's great versatility stands out through the entire book. In rapid succession he appears as a flier of gliders, a photographer, an expert in optics, an amateur detective, a boomerang specialist, author of scientific fiction, artist, solver of the mystery of Tutankhamen's purple gold sequins, and so forth. His book of nonsense verse, *How to Tell the Birds from the Flowers* (Dodd, Mead), has seen 19 editions. An excerpt:

Some are unable, as you know,
To tell the Crocus from the Crow;
The reason why is just be-caws
They are not versed in Nature's laws.
The noisy cawing Crows all come,
Obedient to the Cro'custom,
A large Crow Caw-cus to convoke.
You never hear the Crocus croak!

In physical optics, of course, Wood stands supreme. His book on the subject has long been, and still is, the standard reference work. He has devised many of the experiments that have served to revive interest in a once dead field. Fortunately, some are so simple that a bright boy can reproduce them and learn much by so doing. The creation of an artificial mirage is one example. The "fish-eye camera" is another.

Doctor Wood deserves a front place in every scientific library. You will have to read it to understand the high compliment that Dr. Karl Darrow paid Wood, at the presentation of the Ives medal of the Optical Society of America. Darrow said: "The term, 'a Wood experiment,' has come to be employed of any which is distinguished by unusual ingenuity and efficacy, and especially if it is made by simple means."

DONALD H. MENZEL
Harvard College Observatory

INTRODUCTION TO METEOROLOGY

SVERRE PETTERSSEN. McGraw-Hill Book Company, New York, 1941. 236 pages. $2.50.

WHOEVER wants to be introduced by a reliable authority to modern weather science should consider this book. Whoever wants in particular to find out what meteorological science has to say about that most practical and intriguing problem of forecasting the weather should certainly read this book. In order to head the meteorology department of the Massachusetts Institute of Technology, Prof. Petterssen was called, a few years ago, from Scandinavia, where the theory and practice of air mass analysis sprang to life during the first World War. He has been a pioneer and is one of the world's authorities on quantitative methods of forecasting.

Introduction to Meteorology is virtually a condensed and simplified version of Prof. Petterssen's previous book entitled *Weather Analysis and Forecasting*. It is "intended for students without previous acquaintance with the subject." Although English is not his native language, the author has a terse, clear, and orderly style that imparts to the reader without effort the fascinating intricacies of the workings of the gases that flow over the surface of the earth. Mathematics is reduced to a minimum, diagrams serving in large measure to describe how the elements of the air behave. Anyone who can understand a simple graph or alge-

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MANUAL OF ASTRONOMY, *R. William Shaw and Samuel L. Boothroyd.* 1941, *by the authors at Cornell University, Ithaca, N. Y.* 305 pp. $3.00.

A comprehensive and well-organized manual suitable for use by amateur astronomers as well as in college courses. The book contains 44 exercises on all phases of astronomy.

JEAN DOMENIQUE CASSINI AND HIS WORLD MAP, *Lloyd A. Brown.* 1941, *University of Michigan Press.* 79 pp. $5.00, including map.

A monograph on the designer of the Cassini planisphere of 1696, and the map's background. This map may be called the beginning of scientific cartography.

MATTER, ENERGY, AND RADIATION, *J. R. Dunning and H. C. Paxton.* 1941, McGraw-Hill. 668 pp. $3.50.

A well-illustrated and well-diagramed book, designed as a text for college general science courses, and suitable for study by the layman. A list for suggested reading, and questions, close each chapter.

braic equation can follow through without hesitation.

First is presented the groundwork—an understanding of the composition and general structure of the atmosphere. Over 30 pages are devoted to outlining the mechanisms of barometers, thermographs, hygrographs, and other instruments, and methods of measuring weather elements, together with an explanation of the units. All these are well illustrated with diagrams and photographs, including the classification of cloud types.

Then is introduced the behavior of water in the air—evaporation, condensation, and precipitation—followed by chapters covering the physical bases of weather phenomena resulting from temperature and moisture relations, including: why air cools when it ascends, but cools less rapidly if it is air saturated with moisture; why air is in some cases stable and in others unstable, and vertical motions are easily set off; what happens to the sun's heat that falls on the earth and how it directly or indirectly supplies the energy that causes convection, clouds, thunderstorms.

The emphasis of this book on practical questions, especially those concerned with aviation, is illustrated by the relatively lengthy discussion of fog and icing, amounting to 13 pages or over 40 per cent of the chapter on temperature variations and their relation to weather phenomena, and the inclusion, in the chapter on winds, of notes on the significance of wind turbulence and bumpiness. Here is explained the relation of the air currents to the pressure, including how the air currents are turned by the rotation of the earth.

After this general introduction to the elements of weather, Prof. Petterssen unfolds the recently developed conceptions of the great tongues of cold, dry air that spread out from polar regions, and of warm and moist tongues that reach up from tropical regions, of what happens at the boundaries or fronts between these two different types of air, and how there develops along these boundaries the familiar cyclonic storms of middle latitudes. Of course the nature of other types of cyclones, such as hurricanes and tornadoes, and the anticyclones are explained.

With this knowledge of the workings of the atmosphere in mind, the reader is told how the weather is, in practice, mapped, analyzed, and forecast. There are a couple of brief supplementary chapters giving a rough idea of climatology and some notes on the history of the science of weather.

The book will serve excellently either for a beginning for the serious student or for a look-in for the amateur.

METEOROLOGY

DONALD S. PISTON. The Blakiston Company, Philadelphia, 1941. 2nd edition. 233 pages. $3.00.

THIS is a picture of meteorology taken from a different angle by a different camera from the one used by Petterssen. Dr. Piston has been a college teacher of physics, and it is from this point of view that he writes. While his acquaintance with meteorology is not so intimate, his interest in explaining in brief form the phenomena of the atmosphere on the basis of the well-known laws of physics gives the book its value. The subject matters are nearly the same as those included in the Petterssen book, but are treated in such a way as to be more interesting for someone who has studied a little physics and wishes to see how it is applied to weather phenomena, rather than for someone interested in a streamlined groundwork for the practical business of forecasting. The Piston book is also elementary, plentifully illustrated, clear, and easily read, and makes a good introduction to the subject.

THE METEOROLOGICAL GLOSSARY

METEOROLOGICAL OFFICE, LONDON. First American (3rd English) edition. Chemical Publishing Co., Inc., New York, 1940. 251 pages. $3.00.

THIS is a useful handbook for anyone interested in weather science. Meteorological terms are defined and discussed in much the form you would expect if you cut out from a good encyclopedia all meteorological terms treated therein and, after adding a number of more special terms, put them together in a single encyclopedia of meteorology. It is a highly authoritative work and contains a wealth of information.

RALPH W. BURHOE
Blue Hill Meteorological Observatory

ANSWERS TO DO YOU KNOW?

(*Questions on page* 17)

I. 1, d; 2, a; 3, b; 4, a; 5, c; 6, d; 7, d; 8, c; 9, c; 10, c.

II. imagination, cubic, millimeter, ordinary, matter, temperature, fifty, million*, degrees, approximate (temperature), center, incredible, though, merely, maintain, pinhead, (matter), (temperature), replenish, energy, loses, radiation, faces, would, require, three, quadrillion, horsepower, (pinhead), (matter), (would), anyone, ventured, within, thousand.

* At present, 20 million degrees is considered the temperature of the sun's center.

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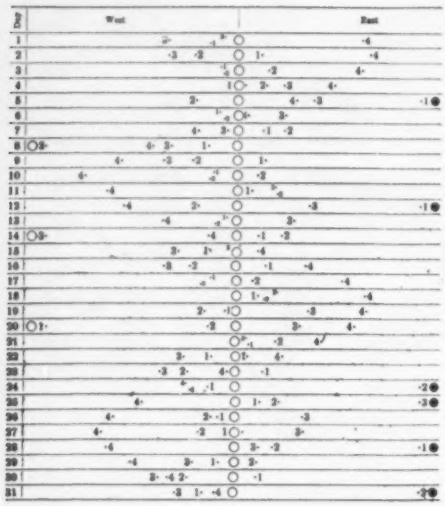
OBSERVER'S PAGE

By Jesse A. Fitzpatrick

All times mentioned on the Observer's Page are Eastern War Time.

JUPITER'S SATELLITES

Jupiter's four bright moons have these positions at 11:00 p.m. E.W.T., on the day preceding the date shown below. The motion of each satellite is from the dot to the number designating it. Transits of satellites over Jupiter's disk are shown by open circles at the left, and eclipses and occultations by black disks at the right. From the **American Ephemeris.**



On March 3rd, before 11:11 p.m., and on March 17th and 20th throughout the evening, the four bright moons will be east of the planet. On March 3rd, they will be in numerical order, *I* being nearest the primary.

On March 7th, after 11:02 p.m., the four moons will be west of the planet. This configuration will also exist prior to 7:51 p.m. on March 23rd and prior to 10:34 p.m. on the 30th, preceding in each case the occultation of *II*.

On March 31st, all moons will be on the east side following the occultation reappearance of *III*.

On March 22nd, at 9:30.7 p.m., *IV* will be in inferior geocentric conjunction, the satellite appearing just south of the disk. This is the last of these very interesting conjunctions, both inferior and superior, that we may observe until 1945. After the end of June, the moon will start to transit across the face of the primary at inferior conjunctions, or be occulted during superior passages. All conjunctions in the interim will occur either in daylight or after Jupiter has set.

From our local station we will be unable to see the superior conjunction which occurs at 10:05.9 p.m., May 3rd, almost the exact moment of Jupiter's setting. The satellite will appear only two seconds of arc north of the planet, a separation requiring a 4-inch telescope to resolve.

PHASES OF THE MOON

Full moon	March 2, 8:20 p.m.
Last quarter	March 9, 6:00 p.m.
New moon	March 16, 7:50 p.m.
First quarter	March 24, 8:01 p.m.

MINIMA OF ALGOL

March 3, 1:41 a.m.; 5, 11:30 p.m.; 8, 8:19 p.m.; 23, 4:26 a.m.; 26, 1:15 a.m.; 28, 10:04 p.m.; 31, 6:53 p.m. (These times are based on my Barbados observations, as discussed in the February issue.)

THE PLANETS IN MARCH

Mercury will be at greatest western elongation, 27° 21′, on March 7th. Its southerly declination, —15° 30′, will bring it too close to the horizon for good observation in mid-northern latitudes.

Venus, in Capricornus and Aquarius, will reach the phase of greatest brilliancy on March 9th. It will be in conjunction with the moon on March 13th at 11:51 a.m. at our local station, at which moment it will be a little more than two degrees north of the moon. This fairly close conjunction will enable us to see the planet in broad daylight as we did on December 21st. Conditions will be almost exactly reversed: this time a waning crescent moon instead of a growing crescent, and the planet north instead of south of the moon. The conjunction will be west of the local meridian and will occur 29 minutes later than the geocentric conjunction noted on page 508 in the *Ephemeris*.

Mars, in Taurus, will move during the early part of the month between the Pleiades and the four stars, 14 H¹, 22 H¹, 13, and 14, which I noted in the November issue as being guiding stars for the planet Uranus. Mars will be north of 14 H¹ on March 1st by 40 seconds, a very close conjunction, and 18 minutes north of 22 H¹ on March 3rd. On March 2nd, it will be in conjunction with and 1° 37′ north of Uranus. Its stellar magnitude will vary from +1.1 to +1.5 through the month.

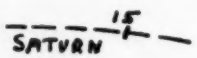
Jupiter is in Taurus.

Saturn is in Taurus.

Uranus. See diagram and special article in the issue of November, 1941. The planet will be 12 minutes south of the star 13 on March 13th and six minutes south of the star 14 on March 23rd.

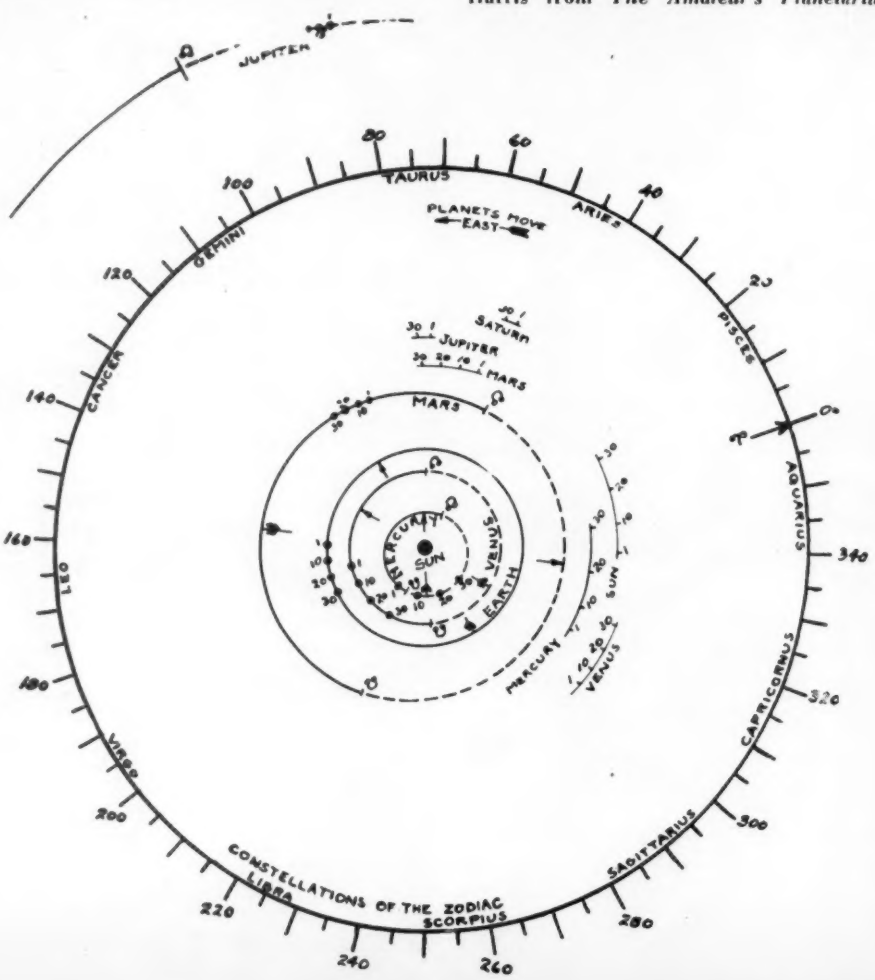
Neptune. See diagram and special article in the February issue. On March 19th the planet will be in opposition to the sun, when its distance from the earth will be 29.25 astronomical units.

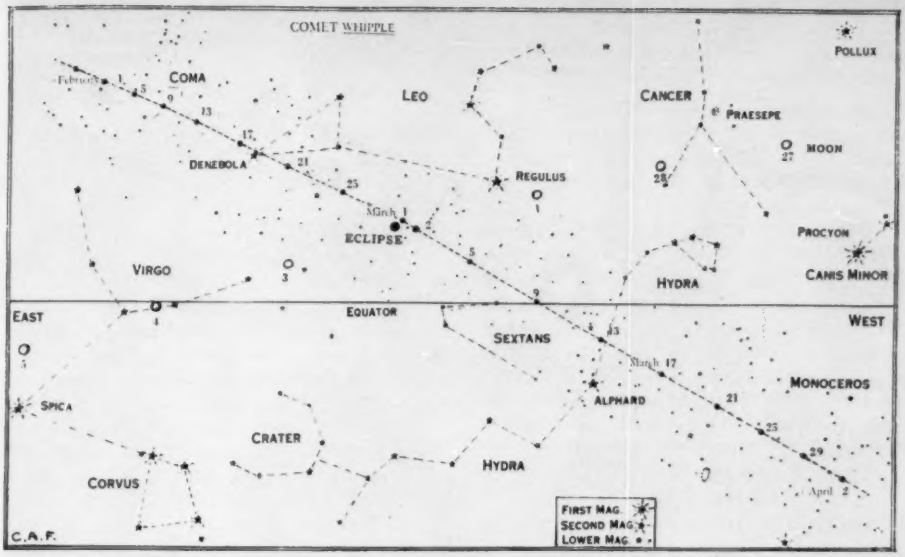
On March 21st at 2:11 a.m., the sun will arrive at the vernal equinox, R.A. 0h 0m, Dec. 0°.



In the chart below, the orbits of the planets are drawn to scale, and on the orbits are shown the heliocentric positions of the planets. Ascending and descending nodes are also marked by the usual symbols.

For convenience, *geocentric* positions are also shown. Suppose, instead of the sun, we had the earth at the center of the diagram. Then straight lines drawn from it through the short arcs just outside the Mars orbit show the positions of the planets against the zodiac at the various dates. Chart by Sylvan Harris from *The Amateur's Planetarium*.





THE PATH OF WHIPPLE'S COMET—1942a

This chart shows the path of the first comet this year. If the comet increases in brightness inversely as the fourth power of the distance from the sun, it will not attain naked-eye visibility, but should be observable with good binoculars.

Note the position of the comet on March 2nd, just 2½ degrees west of the moon during the total lunar eclipse. See "News Notes" in this issue for further details.

Positions computed by R. N. Thomas for 8:00 p.m., on the dates shown, are:

	h	*m*	°	′	*Mag.*
Feb. 25	11	8.7	+11	26	7.6
Mar. 1	10	43.0	+ 8	7	7.5
5	10	15.8	+ 4	25	7.3
9	9	48.1	+ 0	21	7.2
13	9	21.2	— 3	19	7.2
17	8	56.2	— 6	53	7.2
21	8	33.8	—10	3	7.3
25	8	14.2	—12	47	7.4
29	7	57.4	—15	6	7.5

OCCULTATIONS—MARCH, 1942

Local station—lat. 40° 48′.6, long. 4h 55.8m west.

Date	*Mag.*	*Name*	*Immersion*	*P.**	*Emersion*	*P.**
March 2	5.1	c (59) Leonis	9:03.1 p.m.	65°	9:53.9 p.m.	335°
3	3.8	β Virginis	7:58 p.m.	137°	8:49.2 p.m.	261°
5	6.2	38 Virginis	1:04.4 a.m.	126°	2:20.8 a.m.	288°
8	6.4	190 B Librae	2:38.5 a.m.	64°	3:28.7 a.m.	335°
9	5.0	24 Scorpii	2:36.5 a.m.	145°	3:28.6 a.m.	246°
19	5.7	64 Ceti	6:55.2 p.m.	83°	8:04.5 p.m.	243°
19	4.5	ξ¹ Ceti	8:02.9 p.m.	49°	9:00.8 p.m.	280°
22	1.1	Aldebaran	5:54.7 p.m.	51°	7:16.1 p.m.	287°
26	5.9	5 Cancri	7:51.8 p.m.	75°	9:13.3 p.m.	308°
30	5.8	89 Leonis	10:44.3 p.m.	116°	12:05 a.m.(31)	296°

*P is the position angle of the point of contact on the moon's disk measured eastward from the north point.

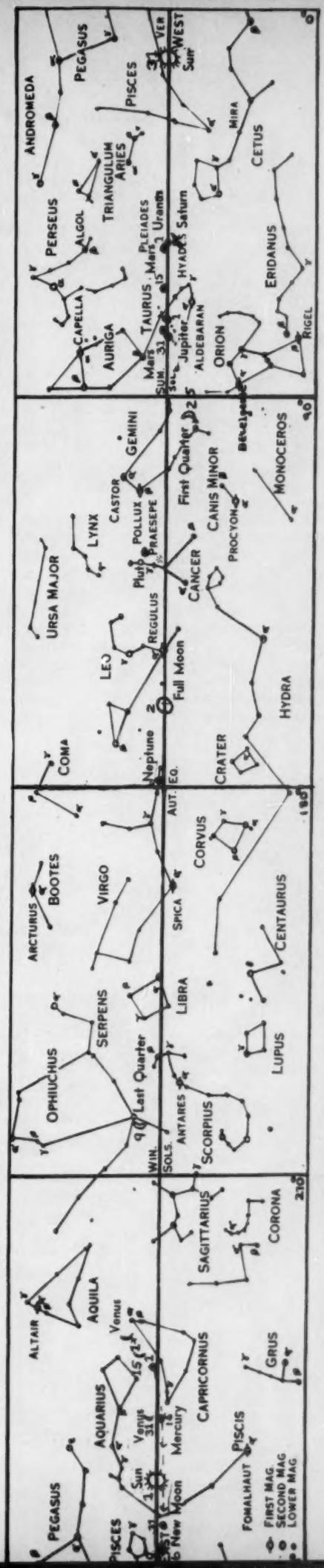
The occultation of 59 Leonis on March 2nd will be of particular interest, happening as it does during the lunar eclipse. Immersion will occur a few minutes before the total eclipse ends, and emersion, 18 minutes before the moon leaves the umbral shadow. During the eclipse, Whipple's comet should be visible, about 2½ degrees west of the moon.

The star 292 B Orionis, magnitude 6.5, will be in conjunction with the moon at our local station at 10:11.5 p.m. on March 24th. At that moment, the star will be south of the moon's edge by a distance equal to four per cent of the moon's diameter, or about the width of the crater Plato. The position angle of the moon's axis being only 2°.5, the conjunction will be very near the moon's south pole.

The planet Neptune will be in conjunction with the moon at 2:39.5 a.m., March 4th, at our local station. At that moment, the planet will be north of the moon's edge by a distance equal to 57.5 per cent of the moon's diameter, or north of the moon's center by an angular separation of about 32 minutes. The position angle of the moon's axis will be at maximum, 25 degrees east. This will cause the conjunction to be on a line drawn from the moon's center through the crater Schiller and the west end of the crater Bailly. The data on page 508 of the *Ephemeris*, noting this conjunction to occur at 2:29 a.m. and the planet to be four minutes south of the moon's center, is from a geocentric standpoint. In order to see this particular condition, an observer must be in longitude 78° 58′.5 west and latitude 6° north.

THE ECLIPTIC CHART

at the right is drawn with the ecliptic as its central line, instead of the celestial equator. Perpendicular to this are lines marking celestial longitude. The positions of the sun, moon, and inner planets are shown for the beginning, middle, and end of the month. The outer planets do not change materially from the positions shown during that time. Computations for plotting the planets are by Sidney Scheuer. On the next page is the star chart for this month.



THE APPARENT POSITIONS IN THE HEAVENS OF THE SUN, MOON, AND PLANETS.

THE STARRY HEAVENS IN MARCH

By Leland S. Copeland

WINTER'S bright host of stars is in full retreat as we look at the night sky of March. Led by Chief Sirius and his aides, Rigel, Betelgeuse, and Aldebaran, the resplendent army is yielding to irresistible force. By mid-March at 10 p.m., War Time, the main line will be more than halfway down the western hills, and by late May it will have passed from sight. But in March the rear guard, marshaled by Capella, Pollux, and Procyon, still remains near the meridian, which the main body so gloriously held late in January.

There still is time to admire part of Gould's Belt. In this band are the outstanding stars of Taurus, Orion, Canis Major, Scorpius, Cassiopeia, and other constellations. It crosses the Milky Way in Cepheus and Argo at an angle of 14 degrees.

Gould's Belt marks the central plane of a star cloud, the local system. This cloud, 3,000 by 800 light-years, includes the sun and most of the stars forming our constellations. Its center is in the direction of Carina.

In the eastern sky sparkles the great "diamond of Virgo," formed by Denebola in Leo, Cor Caroli in Canes Venatici, Arcturus in Bootes, and Spica in Virgo, slightly above the horizon in mid-March. Stretching from the southeastern horizon to the meridian, lurks Hydra, the Water Snake, with its orange heart, Alphard. On its back are dim Crater, the Cup, and bright Corvus, the Crow.

The gloomy Crab hides close to the zenith; chief feature of Cancer is Praesepe, the Manger, or Beehive, a blurry spot that can be resolved with binoculars. The Manger forms a small triangle with two stars called the Asses. Slightly west of α in Cancer is M 67, another handsome open cluster. This nest of apparently dim suns is found easily with an amateur telescope.

In the northwest, Aries nears the horizon, head foremost, and, following the Ram, the Bull is descending backward.

PASTURES OF THE SKY

TAURUS and Aries awaken memories of the everyday life and the strange rites and fancies of long ago. When the constellations were being named, much wealth consisted of herds and flocks, for which starry representatives seemed desirable. Also, during a large part of ancient times either Taurus or Aries contained the vernal equinox, point where the northbound sun passes over the celestial equator. This crossing may have been reflected in the daydreams of men.

For ages Taurus has been famous for two beautiful clusters, the Pleiades and the "stormy" Hyades, and for ruddy Aldebaran, right eye of the Bull and eastern end of the V-shaped Hyades.

Aldebaran, which means *follower* (of the Pleiades), is a double star, resolvable in an amateur's telescope. It is not a member of the Hyades cluster.

Nowadays, Taurus is celebrated also for the Crab nebula, between the tips of the horns and close to ζ. According to modern belief, this planetary was produced by an exploding star. Chinese and Japanese watchers saw a nova near ζ in 1054 A.D.; so astronomers believe that this nebula is nearly 900 years old.

Under the Hyades two bent lines of stars form the legs of the Bull. There are no hindquarters. An old story tells why.

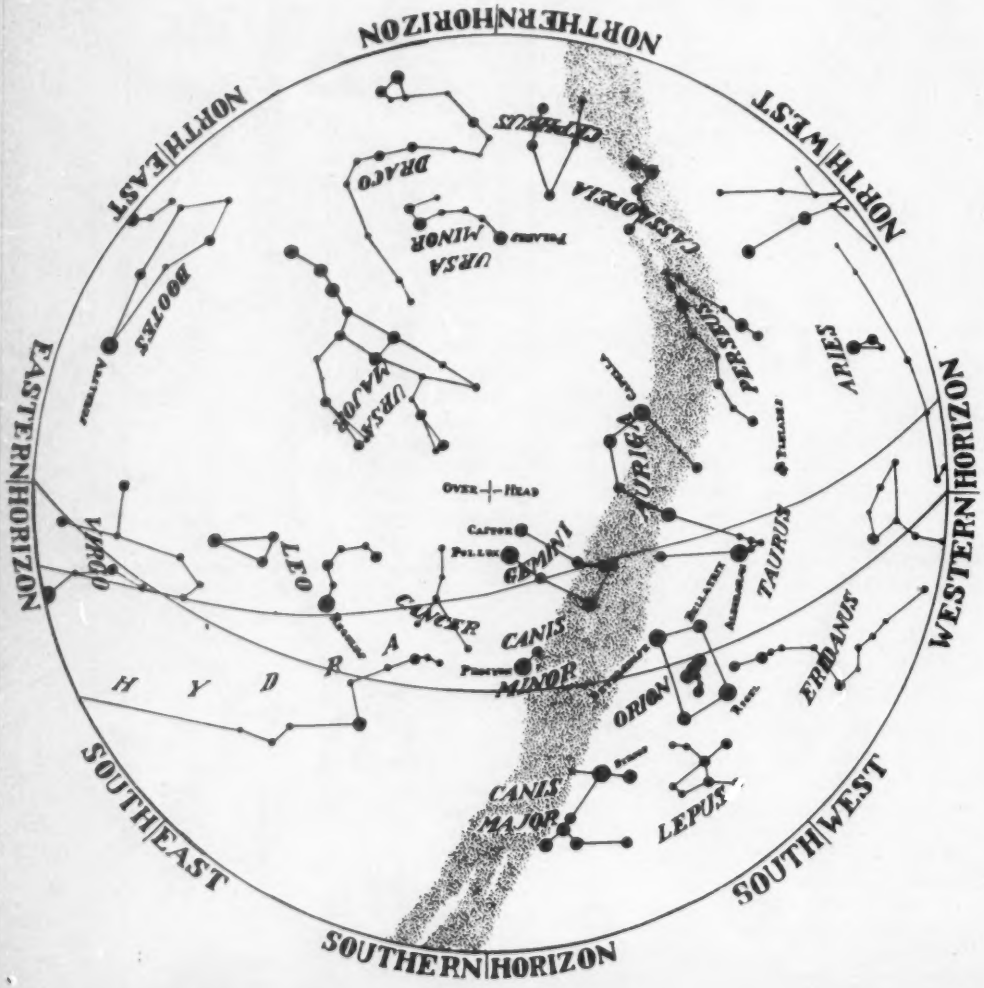
Without invitation, Jupiter, as a snow-white bull, joined a party of girls gathering flowers in Phoenicia. Among them was Europa (who gave her name to a continent). Jupiter was in love with her —or thought so then. After persuading her to sit on his back, he plunged with her into the Mediterranean and swam to Crete. Pleased with this elopement, he placed his disguise in the sky. Only the head and forequarters show because water covered half of him as he swam.

To appreciate such legends we must remember that they are fossils of human thought. The Greeks believed strongly in the fatherhood of God. At first they accepted this doctrine literally, perhaps because it seemed to explain geniuses and their own superiority. Later they expressed the same idea richly in the poetry of Aratus and Cleanthes.

For more than 2,000 years the vernal equinox slipped westward in Taurus. Then for a similar age it moved in Aries. Each year when the sun traveled north across the equator, it "slew"—obliterated with light—the Bull in the first era, the Ram in the second. Did these events influence religious thinking?

Mithra, Persian sun-god, vanquished a bull. Each Hebrew family killed a lamb at the Passover (when the sun passed over the equator). And Christ, the Lamb of God, was put to death as spring began. His followers are "washed in the blood of the Lamb," as worshippers of Attis were bathed in the blood from a bull slain at the vernal equinox.

Probably most of these odd harmonies were mere coincidences. Across the dimming centuries we look in vain for their earliest sources in the foggy morning of thought.



THE STARS FOR MARCH

as seen from mid-northern latitudes at 10 p.m., March 7th; 9 p.m., March 23rd. Magnitudes of the stars are indicated by the sizes of the disks marking the stars, and the names of some of the brighter stars appear. The ecliptic and the equator are shown, the latter touching the horizon at the east and west points. See chart on the "Observer's Page" for the positions of the sun, moon, and planets this month.

HERE AND THERE WITH AMATEURS

This is not intended as a complete list of societies, but rather to serve as a guide for persons near these centers, and to provide information for traveling amateurs who may wish to visit other groups.

City	*Organization*	*Date*	*Hour*	*Season*	*Meeting Place*	*Communicate with*
BOSTON	BOND AST. CLUB	1st Thu.	8:15 p.m.	Oct.-June	Harvard Observatory	Homer D. Ricker, Harvard Observatory
"	A.T.M.s OF BOSTON	2nd Thu.	8:15 p.m.	Sept.-June	Harvard Observatory	F. I. Noyes, 340 Warren St., Brockton, Mass.
BROOKLYN, N. Y.	ASTR. DEPT., B'KLYN INST.	Round Table 3rd Thu.	8:00 p.m.	Oct.-April	Brooklyn Institute	William Henry, 154 Nassau St., N. Y. C., *BA.* 7-9473
BUFFALO	A.T.M.s & OBSERVERS	1st & 3rd Fri.	8:00 p.m.	Oct.-June	Museum of Science	J. J. Davis, Museum of Science
CHATTANOOGA	BARNARD A. S.	4th Fri.	7:30 p.m.	All year	Chattanooga Obs.	C. T. Jones, 1220 James Bldg., *CHat.* 6-8341
CHICAGO	BURNHAM A. S.	2nd & 4th Tue.	8:00 p.m.	Sept.-June	Congress Hotel	Wm. Callum, 1435 Winona Ave.
CLEVELAND	CLEVELAND A. S.	Fri.	8:00 p.m.	Sept.-June	Warner & Swasey Obs.	Mrs. Royce Parkin, The Cleveland Club
DAYTONA BEACH, FLA.	D. B. STARGAZERS	Alt. Mon.	8:00 p.m.	Nov.-June	500 S. Ridgewood Ave.	Rolland E. Stevens, 500 S. Ridgewood
DETROIT	DETROIT A. S	2nd Sun.	3:00 p.m.	Sept.-June	Wayne U., Rm. 187	E. R. Phelps, Wayne University
"	NORTHWEST A. A. S.	1st & 3rd Tue.	8:00 p.m.	Sept.-June	Redford High Sch.	A. J. Walrath, 14024 Archdale Ave.
DULUTH, MINN.	DULUTH AST. CLUB	1st & 3rd Sat.	8:00 p.m.	All year	Darling Observatory	W. S. Telford, 126 N. 33rd Ave. E.
FT. WORTH	TEX. OBSERVERS	No reg. meetings	.....			Oscar E. Monnig, 1010 Morningside Dr.
GADSDEN, ALA.	ALA. A. A.	1st Thu.	7:30 p.m.	All year	Ala. Power Auditorium	Brent L. Harrell, 1176 *W* or 55
INDIANAPOLIS	INDIANA A. A.	1st Sun.	2:00 p.m.	All year	Central Library Audit.	E. W. Johnson, 808 Peoples Bank Bldg.
LOS ANGELES	L. A. A. S.	2nd Thu.	8:15 p.m.	.....	2606 W. 8th St.	Charles Ross, 2606 W. 8th St.
LOUISVILLE, KY.	L'VILLE A. S.	3rd Tue.	8:00 p.m.	Sept.-May	Women's Bldg., Univ. of Louisville	Mary Eberhard, 3-102 Crescent Ct., *Taylor* 4157
MADISON, WIS.	MAD. A. S.	2nd Wed.	8:00 p.m.	All year	Washburn Observatory	C. M. Huffer, Univ. of Wisconsin
MILWAUKEE	MILW. A. S.	1st Thu.	8:00 p.m.	Oct.-May	Marquette U., Eng. Col.	E. A. Halbach, *Hopkins* 4748
MOLINE, ILL.	POP. AST. CLUB	2nd Tue.	7:30 p.m.	All year	Sky Ridge Observatory	Carl H. Gamble, Route 1
NEW HAVEN	NEW HAVEN A. A. S.	1st Sat.	8:00 p.m.	Sept.-June	Yale Observatory	F. R. Burnham, 820 Townsend Ave., 4-2618
NEW YORK	A. A. A.	1st & 3rd Wed.	8:15 p.m.	Oct.-May	Amer. Mus. Nat. Hist.	G. V. Plachy, Hayden Plan., *EN.* 2-8500
" "	JUNIOR AST. CLUB	Alt. Sat.	8:00 p.m.	Oct.-May	Amer. Mus. Nat. Hist.	J. B. Rothschild, Hayden Plan., *EN.* 2-8500
NORWALK, CONN.	NORWALK AST. SOC.	Last Fri.	8:00 p.m.	Sept.-June	Private houses	Mrs. A. Hamilton, 4 Union Pk., 6-4297
OAKLAND, CAL.	EASTBAY A. A.	1st Sat.	8:00 p.m.	Sept.-June	Chabot Observatory	Miss H. E. Neall, 6557 Whitney St.
PHILADELPHIA	A.A. OF F.I.	3rd Fri.	8:00 p.m.	All year	The Franklin Institute	Edwin F. Bailey, *Rit.* 3050
"	RITTENHOUSE A. S.	2nd Fri.	8:00 p.m.	Oct.-May	The Franklin Institute	A. C. Schock, *Rit.* 3050
PITTSBURGH	A. A. A. OF P'BURGH	2nd Fri.	8:00 p.m.	Sept.-June	Buhl Planetarium	F. M. Garland, 1006 Davis Ave., N.S.
PONTIAC, MICH.	PONTIAC A. A. A.	2nd Mon.	8:00 p.m.	All year	Cranbrook Inst. of Sci.	J. P. Coder, 2675 Voorheis Rd., 2-9419
PORTLAND, ME.	A. S. OF MAINE	2nd Fri.	8:00 p.m.	All year	Private Homes	H. M. Harris, 27 Victory Ave., S. Portland
PROVIDENCE, R. I.	SKYSCRAPERS	1st Wed.	8:00 p.m.	All year	Wilson Hall, Brown U.	Ladd Obs., Brown U., *GA.* 1633
READING, PA.	READING-BERKS A. C.	2nd Thu.	8:00 p.m.	Sept.-June	Albright College	Mrs. F. P. Babb, 2708 Filbert Ave.
RENO, NEV.	A. S. OF NEV.	4th Wed.	.....	All year	Univ. of Nevada	G. B. Blair, University of Nevada
ROCHESTER, N. Y.	ROCH. AST. CLUB	Alt. Fri.	8:00 p.m.	Oct.-May	Eastman Bldg., Univ. of Rochester	P. W. Stevens, 1179 Lake Ave., *Glenwood* 5233-*R*
SAN ANTONIO	SAN ANT. A. A.	3rd Mon.	8:00 p.m.	All year	Le Villela	R. B. Poage, 807 Hammond Ave.
SCHENECTADY	S'TADY AST. CLUB	3rd Mon.	8:00 p.m.	All year	Observatory site	C. H. Chapman, 216 Glen Ave., Scotia
SOUTH BEND, IND.	ST. JOSEPH VAL. AST.	Last Tue.	8:00 p.m.	All year	928 Oak St.	Fannie Mae Chupp, 224 Seebirt Pl.
STAMFORD, CONN.	STAMFORD AST. SOC.	4th Wed.	8:00 p.m.	All year	Stamford Museum	Thomas Page, Stamford Mus., 300 Main St.
TACOMA, WASH.	TACOMA A. A.	1st Mon.	.....	All year	Coll. of Puget Sound	Geo. Croston, *Gar.* 4124
WASHINGTON, D. C.	NAT'L. CAP. A. A. A.	1st Sat.	8:00 p.m.	Oct.-June	U. S. Nat'l. Museum	Stephen Nagy, 104 C St., N.E., *Linc.* 9487-J
WICHITA, KANS.	WICHITA A. S.	2nd Tue.	8:00 p.m.	All year	East High Sch., Rm. 214	S. S. Whitehead, 2322 E. Douglas, 33148

Sky and Telescope is official publication of many of these societies.

★ ★

PLANETARIUM NOTES

Sky and Telescope is official bulletin of the Hayden Planetarium in New York City and of the Buhl Planetarium in Pittsburgh, Pa.

★ **THE BUHL PLANETARIUM** presents *March 1st to 14th,* MYTHS AND MARVELS; *March 15th,* GLORY OF EASTER.

Here we listen to the strange star stories of so long ago, as full of interest and beauty in this twentieth century as they were in the misty, forgotten eras of antiquity. With the Planetarium stage we are carried back to the glory that was Greece, when the men of old Athens wove their fanciful tales of the glittering stars above. And in the Planetarium sky we see the characters of those tales—whether king, princess or dragon—come suddenly and colorfully to life; the Buhl Planetarium's Easter production graphically presents the astronomical significance of Easter—Why it comes late this year, the ancient connection between Easter and the phases of the moon, the reasons for this symbolic festival occurring at different times in various years.

★ **THE HAYDEN PLANETARIUM** presents, from *March 1st to April 12th,* SPRING FESTIVAL. (See page 11.)

In March the sun "crosses the line" and spring begins in the northern hemisphere. From ancient time people have celebrated this season of renewed life in nature, from the rites of pagan nature worshippers, down to the present when the Passover and Easter are our spring festivals. The story with its astronomical background will be unfolded in the March Planetarium sky show.

From *April 13th to May 31st,* WEATHER SIGNS IN THE SKY.

From time immemorial the sky has been scanned for weather signs. Clouds, moon, sun, rainbows, halos, and even the stars have played their part (and do yet, for that matter) in forecasting the weather. Today, with the modern science of meteorology, much of this has become lore. But despite the many superstitions that are untrue, you can read weather signs in the sky.

★ SCHEDULE — BUHL PLANETARIUM

Mondays through Fridays ..... 3, 8, and 9 p.m.
Saturdays ..... 2, 3, 8, and 9 p.m.
Sundays and Holidays ..... 3, 4, 8, and 9 p.m.

★ STAFF—*Director,* Arthur L. Draper; *Lecturer,* Nicholas E. Wagman; *Business Manager,* Frank S. McGary; *Public Relations,* John J. Grove; *Curator of Exhibits,* Fitz-Hugh Marshall, Jr.

★ SCHEDULE — HAYDEN PLANETARIUM

Mondays through Fridays ..... 2, 3:30, and 8:30 p.m.
Saturdays ..... 11 a.m., 2, 3, 4, 5, and 8:30 p.m.
Sundays—Mutual Network Broadcast—Coast-to-Coast ..... 9:30-10:00 a.m.
Sundays and Holidays ..... 2, 3, 4, 5, and 8:30 p.m.

★ STAFF—*Honorary Curator,* Clyde Fisher; *Curator,* William H. Barton, Jr.; *Assistant Curators,* Marian Lockwood, Robert R. Coles.

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